Bargaining
(議價談判)

Joseph Tao-yi Wang (王道一)
EE-BGT, Lecture 6

Bargaining (議價談判)

- Bargaining (就是「討價還價」!)
  - Process by which economic agents agree on the terms of a deal (個體間討論條件、達成交易的過程)
- Common even in competitive markets
  - The pit market in NYSE/market experiments
    - (即使在完全競爭市場也很常見，例如紐約股市的交易坑市場)
  - Edgeworth Box (Edgeworth, 1881) was created to show range of possible bargaining outcomes (原本是用來研究談判的!)
- Have you ever bargained with someone? (你有跟別人談判過嗎?)

Bargaining (議價談判)

- Nash (1950, 1951):
  1. (Cooperative) Nash Bargaining Solution (奈許談判解)
  2. (Non-Cooperative) Nash Equilibrium (奈許均衡)
- Nash could have won two Nobel Prizes...
- Nash Program: Is NBS the NE/SPE of a particular game? (奈許大哉問：NBS是否為某賽局的NE/SPE?)
  - Yes: Binmore, Rubinstein and Wolinsky (1986)
- References: BGT, Ch.4, HEE, Ch.4, MGSB, 2^{nd} ed., Ch.14 (參考章節)

2 Bargaining Experiments (兩種談判實驗)

- Cooperative NBS vs. Non-Cooperative NE
  - 對應合作賽局NBS和非合作賽局NE，也有兩種談判實驗：

1. Unstructured Bargaining Experiments (自由談判實驗)
   - Free form procedure determined by players (雙方自行決定談判形式過程)
   - Closer to naturally occurring bargaining (較接近實務上談判)
2. Structured Bargaining Experiments (制式談判實驗)
   - Procedure specified by experimenter (形式過程由實驗者決定)
   - Game theory makes specific predictions (賽局論能做出明確預測)

Negotiation Research in Applied Psychology

3. Negotiation Research: Bazerman et al. (2000)
   - Bazerman, Magliozzi and Neale (1985) (應用心理學研究)
   - Negotiate over several issues (ex: price/quantity)
   - Free form communication with fixed deadline (時限內自由溝通討論)
   - Private point schedule (depends on each issue)
     - 雙方各自知道自己的報酬計分方式，最後須在價格數量等多層面(連續或類別)上達成協議

- Results: Deals not Pareto-efficient (結果:達成的協議不都有效率)
  - Affected by systematic heuristics and other cognitive variables (unrelated to game) (受到無關的經驗法則與認知因素影響)

Negotiation Research (協商談判研究)

- Why not much overlap? (為何沒有交集?)
  - Game theory assumes too much rationality? (賽局論假設完全理性)
  - Solvable games are too simplified (解得出來賽局又太簡單)
  - Hard to apply to Negotiation games? (很難用在協商研究)
- Like the two traditions of experimental economics:
  - Game experiments are too simplified? (正如賽局論實驗太過簡單)
  - Hard to apply to market experiments? (很難用賽局論預測市場實驗結果)
- But research questions are the same! (但兩邊面對一樣的研究問題!!)

Unstructured Bargaining (自由談判)

- Test: Nash Bargaining Solution (NBS) (奈許談判解)
  - The point maximizing the product of utility gains (beyond the disagreement point) (與談判破裂相較讓雙方效用增加量的乘積最大的解)

$$\max_{(x_1,x_2)\in S}(x_1-d_1)(x_2-d_2)$$

- Only point satisfying 4 axioms:
  1. Pareto Optimality (效率性、不受額外無關選項影響)
  2. Symmetry (對稱、不受效用平移伸縮影響)
  3. Independence of Irrelevant Alternatives (IIA) (不受額外無關選項影響)
  4. Independence from affine utility transformation (不受效用平移伸縮影響)

Nash Bargaining Solution (NBS奈許談判解)

$$S^* = \arg \max_{(x_1,x_2)\in S} (x_1 - d_1)(x_2 - d_2)$$
$$= \arg \max_{(x_1,x_2)\in S} [u_1(x_1) - u_1(d_1)][u_2(x_2) - u_2(d_2)]$$

Satisfies:

1. Pareto Optimality: (效率性) $\forall x \in S^*, \nexists y \in S, \underline{y > x} \Leftrightarrow \underline{y_i \geq x_i \forall i, y_j > x_j}$
2. Symmetry: (對稱) $d_1 = d_2, (x_1, x_2) \in S^* \Rightarrow (x_2, x_1) \in S^*$
3. IIA (Independence of Irrelevant Alternatives; 不受額外無關選項影響)

$$S^* \text{ solves } (T, d) \text{ if } S^* \text{ solves } (S, d) \text{ and } S^* \subset T \subset S$$

4. IAT (Independence from affine utility transformation, 不受效用平移伸縮影響)

$$u_1(x) = Ax + B, u_2(x) = Cx + D$$

Unstructured Bargaining (自由談判)

- Roth and Malouf (Psychological Review 1979)
- Player bargain over 100 lottery tickets (雙方談判如何分配100張彩券)
  - Risk neutral if can reduce compound lottery
  - 用彩券可讓人風險中立地決策(假設人們會把複合機率簡化成單一機率)
  - 1 ticket = 1% chance winning a prize (每張=1%機率贏得獎金)
  - Equal (\$1) vs. Unequal Prize (\$1.25/\$3.75)
  - Full Information vs. Partial Information (know own prize)
  - 2x2實驗設計: 獎金相同/不同，資訊透明/不透明
- NBS: 50-50 split (NBS預測: 不管獎金相同與否、資訊透明與否都是「50-50對分」)

Unstructured Bargaining (自由談判)

Information (資訊)	Money Prize (雙方獎金金額)	# of Tickets for Player 2 (成員乙所分得的彩券數目)							% of Disagreement (未達成協議的比例)
		20	25	30	35	40	45	50	
Full Information (資訊透明)	1/1	0	0	1	0	1	0	20	0%
	1.25/3.75	1	6	3	2	2	1	4	14%
Partial Information (資訊不透明)	1/1	0	0	0	0	0	1	14	6%
	1.25/3.75	0	0	0	0	0	3	13	0%

Unstructured Bargaining (自由談判)

- Results: Agreements cluster at 50-50
  - Rare Disagreement (很少未達成協議，大部分 50-50 對分)
- 14% Disagree when both know inequality
  - 雙方清楚知道獎金不平等時，有14%未達成協議(彩券 vs. 金錢平分)
  - Divide tickets or $$$ payoffs equally
  - Sensitive to $$$ payoffs: Violate IAT
    - 結果受金錢多寡影響，違反「不受效用平移伸縮影響(indep. of affine transformation)」公設
- Rawlsian Bargaining Solution explains this
  - Follow-up: Roth and Murnighan (ECMA 1982)

Rawlsian Bargaining Solution (羅斯談判解)

$$S^* = \arg \max_{(x_1,x_2)\in S} (x_1 - d_1)(x_2 - d_2)$$

$$= \arg \max_{(x_1,x_2)\in S} [u_1(x_1) - u_1(d_1)][u_2(x_2) - u_2(d_2)]$$

Satisfies:

1. Pareto Optimality: (效率性) $\forall x \in S^*, \nexists y \in S, \underline{y > x}$
2. Symmetry: (對稱) $d_1 = d_2, (x_1, x_2) \in S^* \Rightarrow (x_2, x_1) \in S^*$
3. IIA S^* solves (T, d) if S^* solves (S, d), $S^* \subset T \subset S$
4. Independence of utility transformation preserving preference order and which player has larger gain

$\underline{x_i \geq y_i \Leftrightarrow u_i(x_i) \geq u_i(y_i)}$ $\underline{x_1 - d_1 \geq x_2 - d_2 \Leftrightarrow u_i(x_1 - d_1) \geq u_i(x_2 - d_2)}$

Unstructured Bargaining (自由談判)

- Murnighan, Roth and Schoumaker (JRU 1988)
  Review earlier studies to find: (回顧先前實驗發現)
- Pairs settle @ final minutes (of 9-12 min) (最後幾分鐘才達成協議)
  - Convey private info (Stubbornness/Delay Cost)? (表示自己很堅持/可以負擔延遲成本?)
- Follow-up: Roth and Schoumaker (AER 1983)
  - First play against computer that gives you a lot (先跟軟弱電腦談判)
- Expect and get this later from human players (被訓練該多拿)
  - Strong Reputation (接下來面對真人態度也會較強硬、並且也真的拿比較多)

Unstructured Bargaining (自由談判)

- Mehta, Starmer and Sugden (book chapter 1992)
- Nash Demand Game: (奈許需求實驗) 2 Players
  - Each state demand (兩人分別列出自己的需求金額，總和 ≤10英鎊就會得到所求)
  - Get their demand If sum $\leq$ £10, 0 otherwise. (不然都得0)
- Focal point: Players split 4 Aces + 4 deuces (兩人抽4張A/4張2)
  - Before bargain, players were told:
  - "4 aces worth £10 together, so to earn $$ you have to pool your aces and agree on how to divide the £10."
    - 焦點:「四張A合起來值十英鎊，想賺錢就得合作、一起換十英鎊來分」

Unstructured Bargaining (自由談判)

- Results: 被告知四張A合起來值十英鎊，因此要賺錢就得把四張A合起來並同意如何平分十英鎊。實驗結果居然受此敘述(與報酬無關)影響!!
- Aces split 2-2:
  - Agree $\boxed{\text{50-50}}$ Split (各兩張A就對分)
- Aces 1-3: (一張/三張)
  - Half 50-50, (一半對分)
  - Half 25-75; (另一半要求25-75)
  - 22% disagree (22%爆掉)

Demand	1A	2A	3A
£2.50	11	0	0
£3.00-4.50	5	1	1
£5.00	16	$\boxed{40}$	17
£5.50-7.00	0	1	11
£7.50	0	0	4
N	32	42	33

Can BGT Explain This? (行為賽局論的解釋)

- Roth (1985) explains as Coordination Game over allocation focal points 50-50 vs. h-$(100$-$h)$
  - Each favoring one ($50 > h$ whenever $50 < 100$-h)
  - 可用協調賽局解釋: 考慮兩個分配上的協調焦點 50-50 或 h-$(100$-$h)$
- Both simultaneously choose to demand their favorite or acquiesce to the less favorable (兩邊同時選擇「要求有利自己的分配」或「願接受另一個分配」)
  - If both demand favorite: Both earn 0 (若都「要求」，兩邊報酬皆為0)
  - If only one demands favorite: Play focal point (只有一方「要求」，則按「要求」分)

Can BGT Explain This? (行為賽局論的解釋)

- If both acquiesce: Earn average of the two focal points $x_1 = (50+h)/2$, $x_2 = (150\text{-}h)/2$
  - 若都「接受另一個」則獲得兩分配平均 $x_1 = (50+h)/2$, $x_2 = (150\text{-}h)/2$
- MSE: Players demand with probability (混合策略均衡)

$$p_1 = \frac{h-50}{150-h} \text{ and } p_2 = \frac{h-50}{h+50}$$

- Disagreement rate $= \dfrac{(h-50)^2}{(150-h)(50+h)}$ (未達成協議的比例)

Can BGT Explain This? (行為賽局論的解釋)

- Roth (book chapter 1985)

- Disagreement rate $= \dfrac{(h-50)^2}{(150-h)(50+h)}$
  (未達成協議的比例)
- Predicted to be 0%→7%→10% (過去結果預測隨$h\uparrow$)
  - for $h = 50$, 75, 80 by pervious experiments
- Data: 7% → 18% → 25% (Right direction!)(符合比較靜態預測)
  - Murnighan et al. (JRU 1988) (理論預測: 未達成協議的比例應該隨$h\uparrow$)
  - $h = 60$, 70, 80, 90 predict 1%, 4%, 10%, 19%
- Actual data not as good: Constant across h (但實驗結果持平)

Cause of Disagreement: Self-Serving Bias

- "What is better for me" = "Fair" (對我有利才叫公平)
  - Add to coordination game explains more disagreement in data (上述協調賽局加入自利偏誤可解釋結果)
- Same in Kagel, Kim and Moser (GEB 1996):
  - Ultimatum over 100 tickets (P/R value differently)
    - 用最後通牒談判分配100張(對雙方價值不同)的彩券
  - If R unaware of H/L, P_H/P_L propose to give 45%/30%
    - 回應者不知對方價值高低時，提議者在價值高時會給45%，但價值低時只給30%
  - If aware of H, R will want >50% (Rejection rate = 40%)
    - 回應者知道對方價值較高會拒絕40%、要求比平分更好，使得40%提議被拒絕

Babcock et al.(AER 1995, Law & Social Inquiry 1997)

- Self-serving Bias Experiment: Loewenstein et al. (JLS 1993)
- Read 27-page actual legal case (讀27頁卷宗:機車騎士告車主)
  - Motorcyclist sues driver: $100,000 injury damage
- Bargain for 30 min. to settle it for ?? dollars
  - $5000 legal fees for every 5-min delay
  - Retired judge imposes award if no agreement
    - 30分鐘談判和解(訴訟金額$100k)，每延遲5分鐘須付$5k律師費(和解不成則由退休法官裁定)
- First Guess what judge would award (事先預測和解不成法官會如何判)
  - US$1 (or 1 Grade Point) for every $10,000 (實驗中1萬元=1美元/加1分)

Gap of E(judgment) Predicts Disagreement

- Baseline: 70% cases settled at period 3-4 (out of 6)
- E(judgment) differ by $20,000 (20% of $100,000)
  - 70%的控制組在第3-4回合達成和解(總共6回合); 雙方預期判決結果落差在2萬元左右(訴訟金額的20%)

Settlement Statistics (和解結果)					E(judgment) Gap (預期判決落差)	
Group (實驗組別)	N	%	periods	(s. e.)	mean (平均)	(s. e.)
Control: Babcock 95'	47	72	3.75	(0.28)	$18,555	(3,787)
(控制組)			(回合)			
Control: Babcock 97'	26	65	4.08	(0.46)	$21,783	(3,956)
(控制組)			(回合)			

(提高和解率、更快和解的辦法)

More Pairs Settled (and More Rapidly) if...

- Don't Know Role when Reading: 94% (in 2.51 pds)
  - But you know own role in reality!
    - 閱讀前不知自己是哪一方: 94%在2.51回合和解(但現實雙方立場已知!)

Settlement Statistics (和解結果)					E(judgment) Gap (預期判決落差)	
Group (實驗組別)	N	%	periods	(s. e.)	mean (平均)	(s. e.)
Control: Babcock 95'	47	72	3.75	(0.28)	\$18,555	(3,787)
Don't Know Roles	47	94	2.51	(0.21)	- \$6,275	(4,179)
Control: Babcock 97'	26	65	4.08	(0.46)	\$21,783	(3,956)

$p<0.01$

$\doteqdot 0$

More Pairs Settled (and More Rapidly) if...

- Or, tell subjects the bias before bargaining and ask them to
- First List Weakness of Own Case: 96% (in 2.39 periods)
  - 談判前告知有此偏誤，並請其列出己方立場弱點: 96%在2.39回合和解

Settlement Statistics (和解結果)					E(judgment) Gap (預期判決落差)	
Group (實驗組別)	N	%	periods	(s. e.)	mean (平均)	(s. e.)
Control: Babcock 95'	47	72	3.75	(0.28)	$18,555	(3,787)
Don't Know Roles	47	94	2.51	(0.21)	- $6,275	(4,179)
Control: Babcock 97'	26	65	4.08	(0.46)	$21,783	(3,956)
1st List Weakness	23	96	2.39	(0.34)	$4,676	(6,091)

$p<0.01$

$\doteq 0$

$p=0.01$

$p=0.02$

$\doteq 0$

Summary for Unstructured Bargaining (小結: 自由談判實驗)

- Focal Points affect bargaining outcome (「焦點」會影響談判結果)
- Chip Value affect bargaining outcome (籌碼/彩券的價值影響談判結果)
  - Violate IAT Axiom of NBS (違反奈許談判解的IAT公設，受效用平移伸縮影響)
- BGT Explanation: Bargainers may fail to coordinate under multiple focal points (行為賽局論: 在多重「焦點」下協商不易達成協議)
- Self-Serving Bias predict costly delay/settle (自利偏誤解釋不和解、延遲)
  - "Outcome favoring me more likely/fair" (對我有利更公平/更可能發生)
  - Caused by knowing my role when reading case (來自閱讀卷宗時已經知道自己是哪一方)

Structured Bargaining: Outline (制式談判: 大綱)

- Finite Alternating-Offer Game (有限回合交互提案，延遲有機會成本)
  - Pie shrinks or fixed cost to delay (lost wages in strike)
- Infinite Alternating-Offer vs. Random Termination
  - How can we generate infinitely repeated games?
- Outside Options
  - Will option value affect bargaining outcome?
- Incomplete Information
  - Buyer Value vs. Seller Cost

Finite Alternating-Offer Game (有限回合交互提案)

- Stahl (book 1972) and Rubinstein (ECMA 1982)
  - Player with higher discount factor δ has advantage
  - Examples: Wealthy Tourists, Children at Toy Store
  - 折現因子愈高的一方在談判中有優勢，例如：觀光客被獅子大開口、小孩在玩具店耍賴
- 2-Period: Binmore, Shaked and Sutton (AER 1985)
  - Player 1 offers a division of 100p to player 2
  - If player 2 rejects, makes counteroffer dividing 25p
  - 成員甲提議如何分配100p，成員乙回應。若拒絕則由他提議分配25p
- SPE: Player 1 offers 25-75; player 2 accepts 25p

2-Period: Binmore, Shaked and Sutton (AER 1985)

- Experimental Results: mode at 50-50, some 25-75 and others in between (實驗結果: 衆數50-50, 有些在25-75, 其他在兩者之間)
- Then, player 2 make hypothetical offer as player 1:
  - Most offer 25-75 (as they would accept as player 2?)
    (然後成員乙在假設性問題「如果你是成員甲會怎麼提議」之下大部分提議25-75符合SPE)
- Conclusion: Experience as player 2 help them learn SPE quickly, even if they do not play SPE initially
  - Is Role-Reversal that powerful in learning?!
  - Triple Confound: Experience, Role Reversal, Incentives

Neelin, Sonnenschein and Spiegel (AER 1988)

- Have 80 intermediate micro students play in order:
  - 2-round: Pie size \$5.00 → \$1.25 (2回合: 分配金額\$5.00→\$1.25)
  - 3-round: Pie size \$5.00 → \$2.50 → \$1.25 (3回合: \$5.00→\$2.50→\$1.25)
  - 5-round: Pie size \$5.00 → \$1.70 → \$0.58 → \$0.20 → \$0.07
    - (5回合: 分配金額\$5.00→\$1.70→\$0.58→\$0.20→\$0.07)
- Same SPE: Player 1 offers \$1.25 and player 2 accepts
  - (三個實驗均有同樣的子賽局完全均衡: 成員甲第一回合提議給成員乙\$1.25，成員乙就接受了)
  - 3-round: Offer \$1.25 in round 2 (倒推法: 在三回合的第二回合會提議\$1.25)
  - 5-round: Offer \$0.07, \$0.13, \$0.45, in round 4, 3, 2
    (倒推法: 在五回合的第四、三、二回合分別會提議 \$0.07, \$0.13, \$0.45)

Neelin, Sonnenschein and Spiegel (AER 1988)

- 5-round: \$5.00→\$1.70→\$0.58→\$0.20→\$0.07
- 3-round: \$5.00→\$2.50→\$1.25
- 2-round: \$5.00→\$1.25

Reject (%)

Offer (\$)	2-Round	3-Round	5-Round
>2.50	-	10%	-
2.50	5%	70%	5%
2.01-2.49	-	5%	-
1.71-2.00	3%	8%	38% 6.7%
1.70	-	-	35% 7.1%
1.51-1.70	-	-	10%
1.26-1.50	45% 11%	8% 67%	5%
1.25	38% 20%	-	-
<1.25	10% 100%	-	8% 100%

- 2-Round:
  - Many \$1.25, few \$2.50 (50-50)
    - Follow SPE, unlike Binmore, et al.
- 3-Round/5-Round:
  - Offer 2nd round pie size
    - As if playing 2-round game!

Neelin, Sonnenschein and Spiegel (AER 1988)

- Neelin et al. (1988) find stronger support for SPE
  - Economics undergrads yield different results (經濟系大學生結果不同)
  - Are they taught backward induction? Also, (因為學過倒推法?)
- Binmore: (還是實驗說明? Binmore請學生極大化自己的報酬)
  - "YOU WOULD BE DOING US A FAVOR IF YOU SIMPLY SET OUT TO MAXIMIZE YOUR WINNINGS."
- Janet Neelin (=Janet Currie): (Neelin說上課會討論相關理論)
  - "You would be discussing the theory this experiment is designed to test in class."

Ochs and Roth (AER 1989): Opening Offers

- 2-Round vs. 3-Round Offers to Split $30
- Discount Factors δ: 0.4 vs. 0.6 (differ across players)
  - Bargain over 100 chips (which worth drops differently)
- 2-Round SPE:
  - 1^{st} offer $= 30\delta_2$
  - Independent of δ_1
- 3-Round SPE:
  - 1^{st} offer $< 30\delta_2$

But Experiments show little difference in Period 1!!

Discount Factor		2-Round 1st Offer		3-Round 1st Offer	
δ_1	δ_2	SPE	Period 1	SPE	Period 1
0.4	0.4	$12.00	$13.19	$7.20	$13.02
0.6	0.4	$12.00	$14.73	$4.80	$14.04
0.6	0.6	$18.00	$13.88	$7.20	$13.93
0.4	0.6	$18.00	$14.67	$10.50	$13.90

Ochs and Roth (AER 1989): Opening Offers

- Significant learning in 3 cases (1 wrong direction)
- 2-Round 1st offer = $30\delta_2$: But data dependent of δ_1!
- 3-Round 1st offer $< 30\delta_2$: Data drops only in 2 cases!
- SPE predicts 25 differences:
  - 17 directions correct in data
  - binomial $p<0.05$

Mild Support?

= C(8,2) − 3 (dotted)

3rd counteroffer adds little

Discount Factor		2-Round 1st Offer		3-Round 1st Offer	
δ_1	δ_2	SPE	Period 10	SPE	Period 10
0.4	0.4	\$12.00	\$12.03	\$7.20	\$12.81
0.6	0.4	\$12.00	\$14.34	\$4.80	\$13.17
0.6	0.6	\$18.00	\$14.70	\$7.20	\$13.70
0.4	0.6	\$18.00	~~\$13.57~~	\$10.50	\$14.23

Ochs and Roth (AER 1989): Rejections/Counteroffers

- 16% opening offers rejected
  - 15% in Binmore et al. (1985); 14% in Neelin et al. (1988)
- Counteroffers rejected more (40% of 2nd/54% of 3rd)
  - Could be Selection Bias: Tough player 2s reject and make stingy offers
  - Or, Negative Reciprocity of player 1s (whose offer got rejected)

Discount Factor		2-Round 1st Offer		3-Round 1st Offer	
δ_1	δ_2	Period 10	Reject	Period 10	Reject
0.4	0.4	\$12.03	10%	\$12.81	12%
0.6	0.4	\$14.34	15%	\$13.17	14%
0.6	0.6	\$14.70	13%	\$13.70	15%
0.4	0.6	\$13.57	20%	\$14.23	29%

Ochs and Roth (AER 1989): Rejections/Counteroffers

- 81% counteroffers are disadvantageous!
  - Less than what was offered to (and rejected by them)
    - 75% in Binmore et al. (1985); 65% in Neelin et al. (1988)
- Why? Could be subjects...
  1. Social Utility: Do not maximize own monetary payoff
     - Example: Also care about relative shares (Bolton, AER 1991)
  2. Limited Computation: Do not think ahead sufficiently
     - See MouseLab study below

Bolton (AER 1991): Tournament Incentives

- Tournament payoffs determined by
  - bargaining performance relative to others in same role
- Social Utility of Bolton (AER 1991)
  - Besides $$ amount, also care about relative shares
- Subjects should never reject equilibrium offers
  - Since rejecting equilibrium offers in a tournament reduces both relative shares and $$ amount

Bolton (AER 1991): Tournament Incentives

- Mixed Experimental Results of Bolton (AER 1991)
  - Inexperience subjects: Tournament similar to control
    - Higher variance, some difference in rejection rates
  - 2nd session: Tournament (25%) closer to SPE
  - 3rd session: Tournament moves back toward equal split
- Carter and McAloon (JEBO 1996):
  - Tournament does not move Ultimatum offers and acceptance toward self-interest as Bolton (1991) predicts

Harrison and McCabe (bkch 1992): Learning?

- Binmore et al. (1985): Learn in 1-round of Role-Reversal
- Ochs and Roth (1989) and Bolton (1991): Little Learning
  - Since subjects suffer only 1-2 rejections over 10 rounds
- Harrison and McCabe (1992): Repeat 7 times between:
  - 3-round bargaining: Pie size 100 $\rightarrow$ 50 $\rightarrow$ 25
  - 2-round bargaining: Pie size 50 $\rightarrow$ 25 (subgame of above!)
- 3-round opening offer converges towards SPE (=25)
  - 47 $\rightarrow$ 40 $\rightarrow$ 41 $\rightarrow$ 35 $\rightarrow$ 34 $\rightarrow$ 30 $\rightarrow$ 29
  - 2-Round opening offer = 24-25 (across all 7 times)

Carpenter (J Conflict Resolution 2003): Fair or SPE?

    - But in Harrison and McCabe, 2-round SPE $= 25 =$ equal split
  - What if subgame opening offer is not the fair offer?
- Carpenter (JCR2003): Alternate between:
  - 2-round bargaining: Pie size 100 $\rightarrow$ 25 or 75
  - 1-round ultimatum: Pie size 25 or 75 (subgame of above!)
- Experimental Results:
  - Opening offers $=$ 40% of pie size in all games
  - 2-round bargaining: Slight, insignificant drift towards SPE
    - So, Harrison and McCabe (1992) worked due to fair offer?

Johnson, Camerer, Sen and Rymon (JET 2002)

- Failure of backward induction?
- Play self-interest robots: Think you are self-interest
  - Subjects should make SPE offers (if they can calculate it)
- 3-Round pie size hidden in boxes: Click to open
  - MouseLab: Observe information acquisition
- 3-round: Pie $(5.00+ε) → $(2.50+ε) → $(1.25+ε)
  - SPE opening offer = $1.25
  - Average opening offers = $2.11 (most b/w $2.00 and $2.50)
  - Overall rejection rate = 12% (50% rejection if offer < $1.80)

Johnson et al. (JET 2002): Where Are They Looking?

- 1st → 2nd → 3rd-round: 12.91 → 6.67 → 1.24 secs
- Slightly more Forward transitions than Backward
  - Subjects in 19%/10% of the trials cannot do backward induction since they never opened 2nd/3rd-round box

Round	Pie size	# of Lookups	Trials with No Lookups	Gaze Time	Transition from Row to Column		
					→ 1	→ 2	→ 3
1	\$5.00	4.38	0%	12.91	-	2.55	0.65
2	\$2.50	3.80	19%	6.67	2.10	-	1.24
3	\$1.25	2.12	10%	1.24	0.50	0.88	-

Forward

Backward

Johnson, Camerer, Sen & Rymon (2002): Icon Graph

1. % Box Shaded = Relative gaze time
2. Box Width = Lookups
3. Arrows Thickness = # of transitions (>1)

- 1^{st} box opened most and gazed at longer
- Transitions mostly b/w 1^{st} and 2^{nd} box

Icon Graph

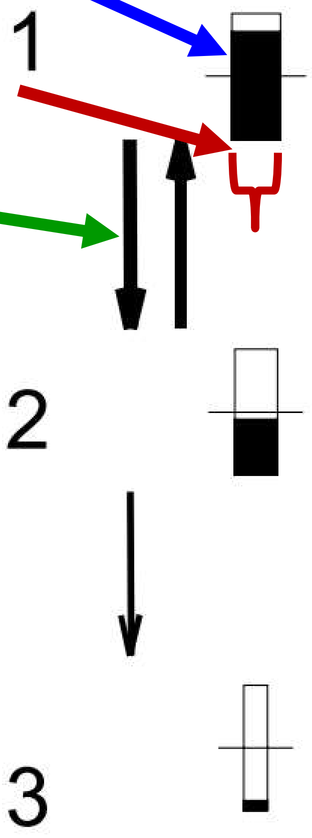
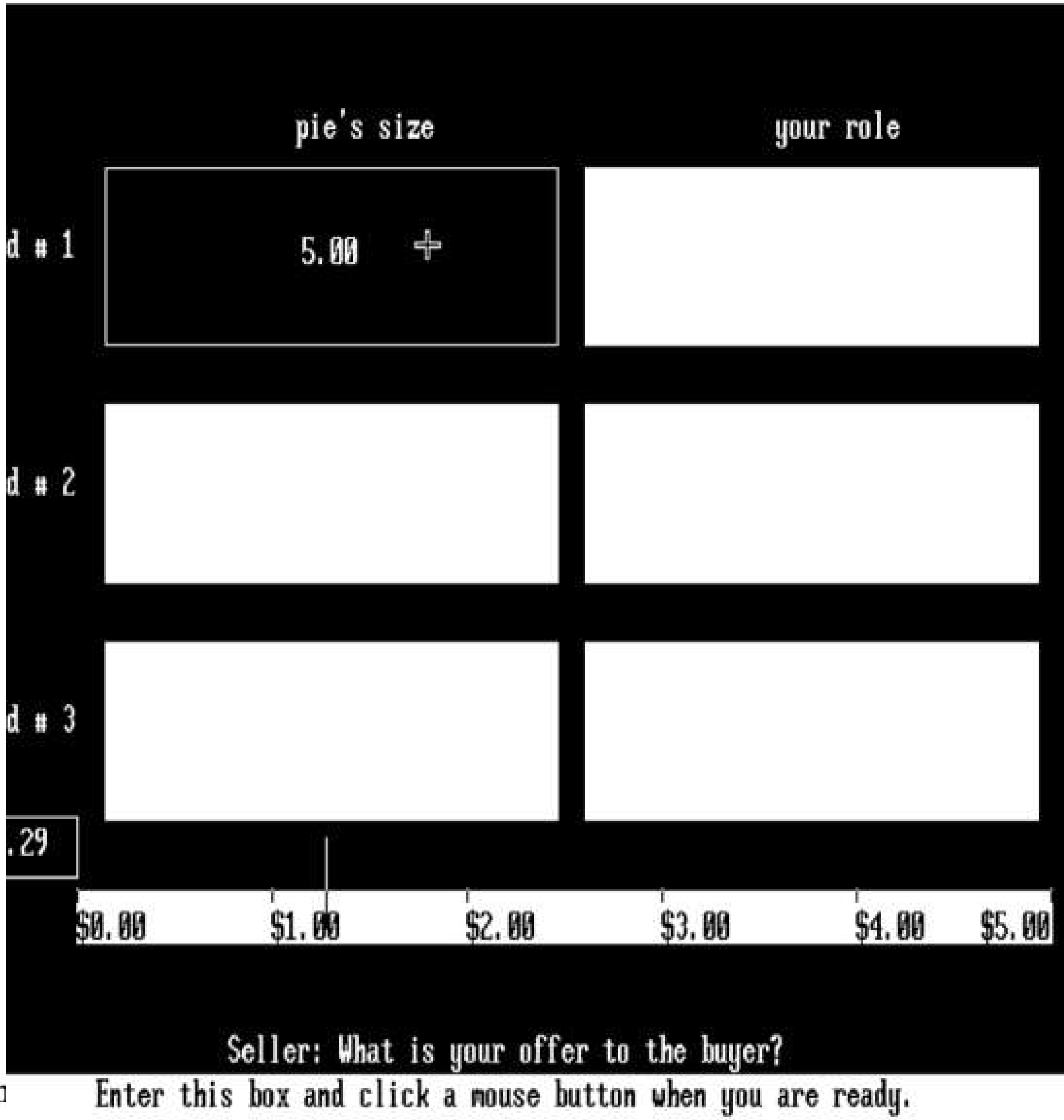


FIG. 3. Icon graph



Johnson et al. (JET 2002): Icon Graph for Player 1

1. % Box Shaded = Relative gaze time
2. Box Width = Lookups
3. Arrows Thickness = # of transitions (>1)

- Level-1 (Offer <$2.00)
  - Look at 2nd box more often and longer than
- Level-0 (Offer ≥$2.00)

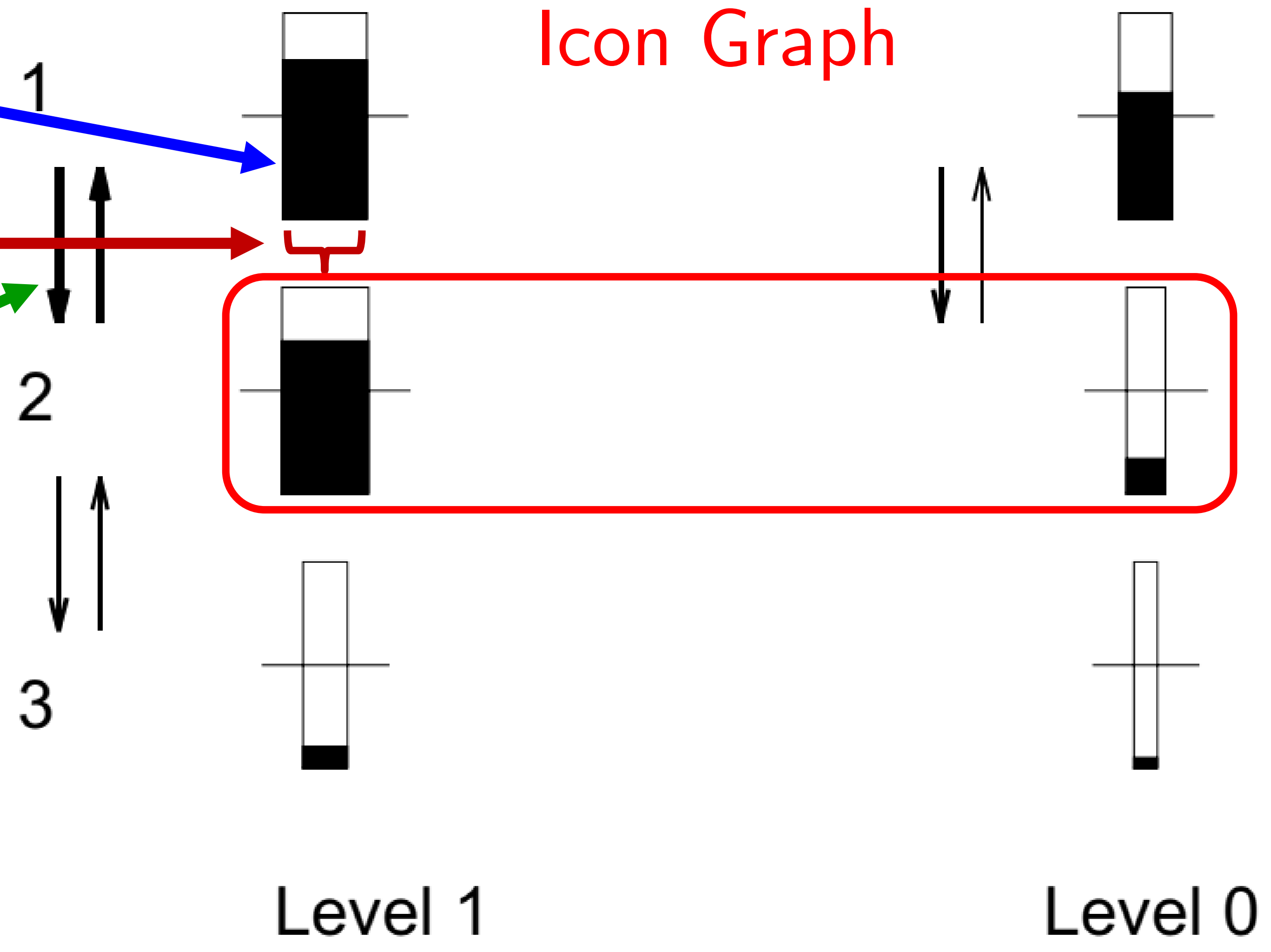


FIG. 4. Icon graphs for player 1 type inferred from first-round offers.

Player 1 Against Robots and Icon Graph for Player 2

- Subjects offer \$1.84 against self-interest robots
  - < \$2.11 (against humans)
  - Still well above SPE (\$1.25)
  - Erasing doubts that opponent are rational insufficient
- Player 2 who accept <\$2.00
- Look at 2nd box more and longer than Player 2 who reject

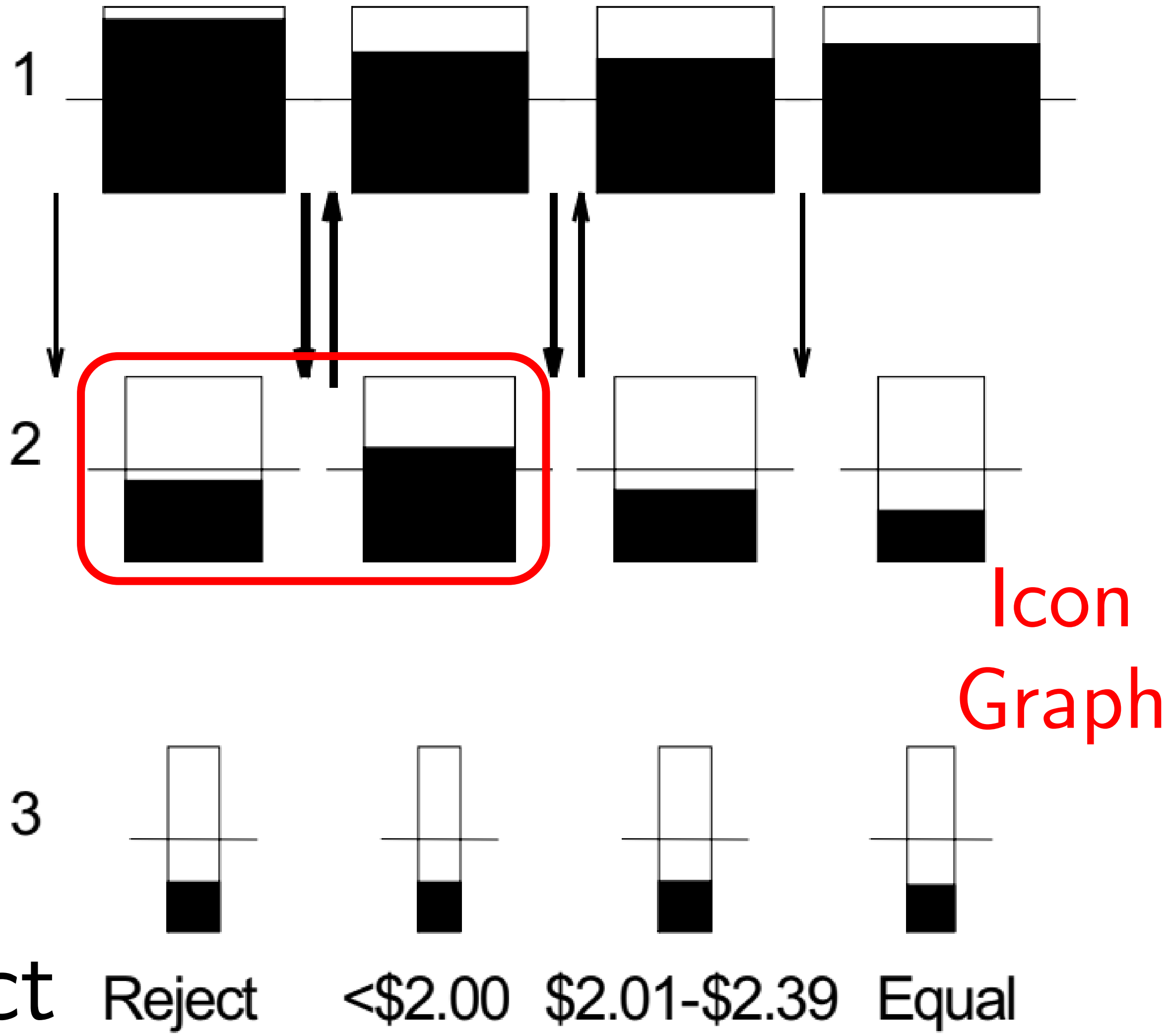
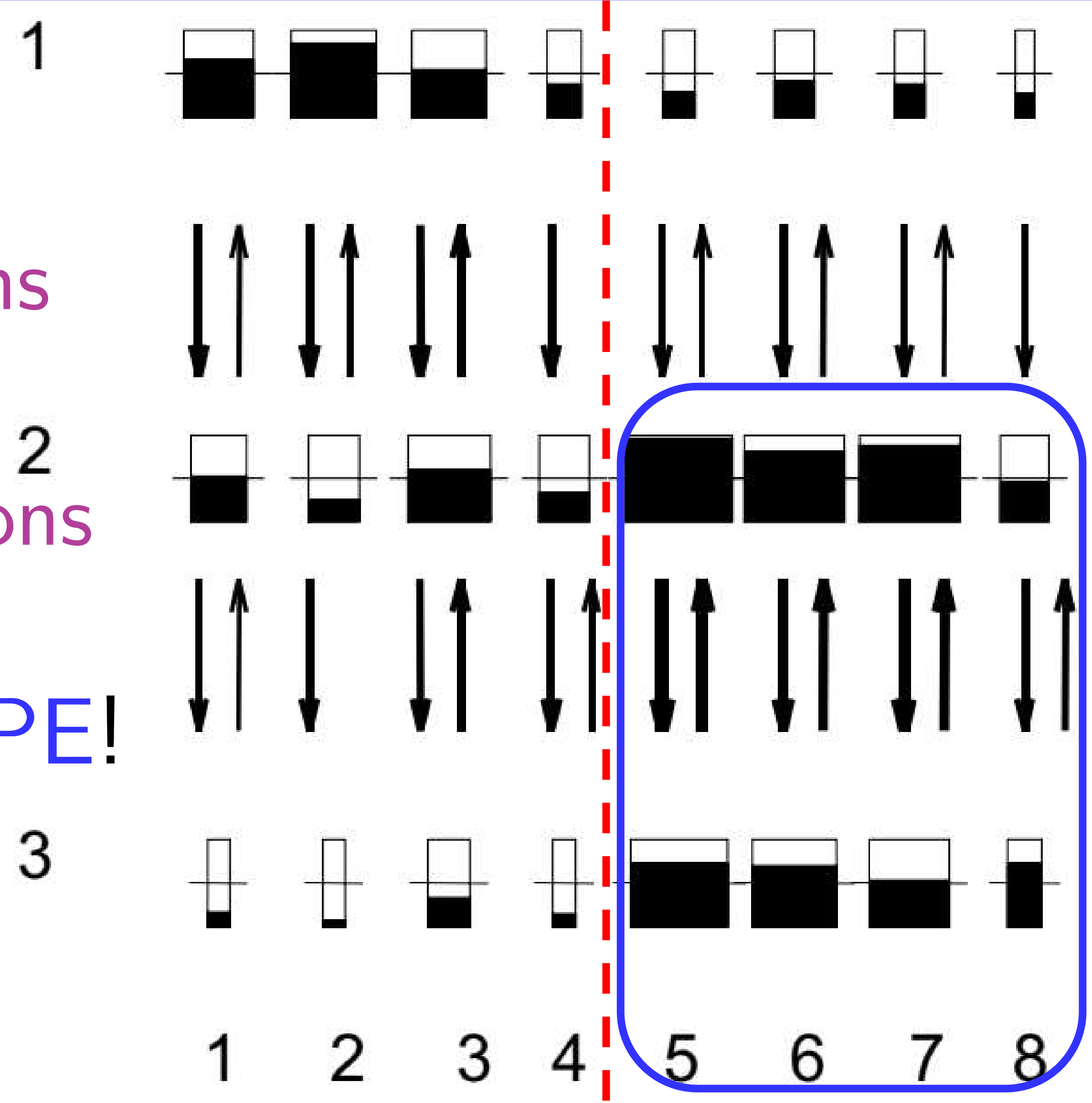


FIG. 5. Icon graphs for player 2 by rejection or size of offer accepted.

Johnson et al. (2002): Teach Backward Induction

1. % Box Shaded = Gaze time
2. Box Width = Lookups
3. Arrows Thickness = Transitions

- Against self-interest robots:
  - After Period 4, receive instructions about backward induction
- Period 5-8: Offer \$1.22 near SPE!
  - Look mostly at $2^{nd}/3^{rd}$ box and transit between them



Johnson et al. (2002): Experienced vs. Inexperienced

- Untrained vs. Trained Subjects:
  - (Trained: Experience playing against self-interest robots)
- Untrained reject low offers from trained (but offer less)
- Trained subjects learn to raise offers after rejection
  - Average offer = \$1.60 (still above SPE!)
- Given such experimental regularities, BGT suggests:
  - Assume subject play truncated games, or
  - Posit decision rules to predict both choices and reasoning processes (and use both choice and lookups to infer rule)

Summary for Alternating-offer Bargaining (小結:輪流出價談判)

- Initial offers between equal split and SPE
- Rejections occur + disadvantageous counteroffers
  - Little learning (except Binmore et al.)
  - May learn when exposed to subgame play even if initial offers accepted (Harrison and McCabe), but only if fair?!
- Limited Computation/How Bargaining Power Emerge:
  1. Players do not look ahead
  2. Do not make equilibrium offers to self-interest robots,
  3. but do make them after training in backward induction

Random Termination vs. Discounting

- Discounting factor δ = randomly terminate w/ prob $(1-\delta)$ (if risk neutral)
- Zwick, Rapoport and Howard (T&D 1992)
  - Divide \$30 with random termination (兩人分配\$30，不限回合但可能隨機結束)
  - Continuation probabilities 0.90, 0.67, 0.17 (下一回合的機率)
  - SPE prediction: (均衡預測) 14.21, 12, 4.29
- Experimental Results: (結果介於50-50平分和均衡之間，最後接受分配與金額縮水的結果類似)
  - Offer <\$15 (between SPE and 50-50); little learning
  - Accepted final offers: 14.97, 14.76, 13.92
  - Close to Pie-shrink discounting results: 14.90, 14.64, 13.57

Fixed Delay Cost in Bargaining (固定延遲成本)

- Instead of pie-shrinking by same discount factor (δ), could pay the same amount of lost wages, profits, etc. (利潤,薪資損失)
- SPE: Strong side (lower delay cost) gets all
  - 均衡預測: 強勢者(延遲成本低)會全拿
- Rapoport, Weg and Felsenthal (T&D 1990)
- Divide 30 shekels (談判分配30舍克勒)
  - Pseudo-infinite horizon: "Experiment will terminated if it lasted too long." (「假裝」無窮期)
- Fixed Cost: \$0.10 vs. \$2.50 or \$0.20 vs. \$3.00 (固定延遲成本)

Fixed Delay Cost in Bargaining (固定延遲成本)

Rapoport, Weg and Felsenthal (1990): \$0.10 vs. \$2.5

- Strong P offer \$4.4 out of \$30, 83% weak R accepts
- Weak P offer \$25.4 out of \$30, 33% Strong R accepts

BGT, Table 4.7

Experiment 1	Decision	Equilibrium Prediction	Periods		
			1-6	7-12	13-18
Strong P	Mean Final Offer	\$0.00	\$9.2	\$7.4	\$4.4
$c_1 = \$0.10 < c_2 = \$2.5$	% accepted on 1st	100%	50%	67%	83%
Weak P	Mean Final Offer	\$29.9	\$20.0	\$23.2	\$25.4
$c_1 = \$2.5 < c_2 = \$0.10$	% accepted on 1st	100%	39%	28%	33%
Equal	Mean Final Offer	[\$0, \$27.5]	\$14.8	\$16.1	\$15.6
$c_1 = c_2 = \$2.5$	% accepted on 1st	100%	78%	83%	83%

Fixed Delay Cost in Bargaining (固定延遲成本)

Rapoport, Weg and Felsenthal (1990): \$0.20 vs. \$3

- Strong P offer \$7.9 out of \$30, 61% weak R accepts
- Weak P offer \$21.6 out of \$30, 28% Strong R accepts

BGT, Table 4.7

Experiment 2	Decision	Equilibrium Prediction	Periods		
			1-6	7-12	13-18
Strong	Mean Final Offer	\$0.00	\$12.8	\$8.6	\$7.9
$c_1 = \$0.20 < c_2 = \$3$	% accepted on 1st	100%	44%	39%	61%
Weak	Mean Final Offer	\$29.8	\$17.9	\$18.5	\$21.6
$c_1 = \$3 < c_2 = \$0.20$	% accepted on 1st	100%	28%	22%	28%
Equal	Mean Final Offer	[\$0, \$27.0]	\$14.8	\$14.6	\$14.7
$c_1 = c_2 = \$3$	% accepted on 1st	100%	94%	94%	94%

Fixed Delay Cost in Bargaining (固定延遲成本)

- Strong support for SPE: In 1st round of bargaining,
  - 實驗結果支持均衡預測: 在談判開始的第一回合,
  - Strong P offer \$4.4/\$7.9, so 61-80% weak R accepts
    - 強勢提議者會提議給對方\$4.4/\$7.9，且60-80%弱勢回應者會接受
  - Weak P offer \$21.6/\$25.4 ($\ll$\$30); 30% strong R accepts
  - Weak P later accepts reality and quickly settles in 2^{nd} (35%) or 3^{rd}-4^{th} (22%) rounds
    - 弱勢提議者會提議給對方\$21.6/\$25.4，由於遠低於\$30會被大部分強勢回應者拒絕。但他們很快就會面對現實，第二回合有35%、第三、四回合又有22%的組別達成協議

Outside Option and Threat Points (威嚇點)

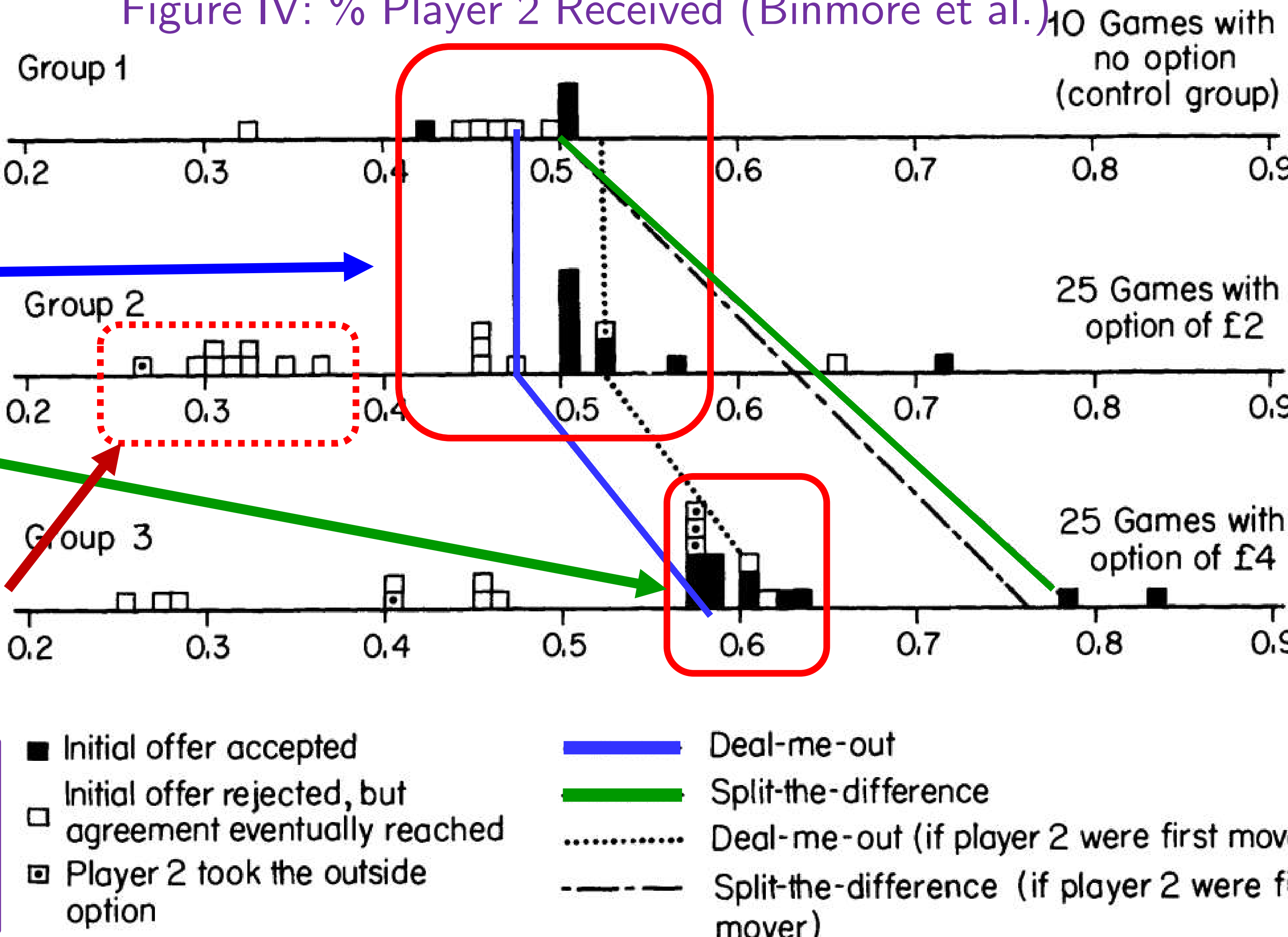
- Binmore, Shaked and Sutton (QJE 1989)
  - 2 players bargain over £7, discount factor $\delta = 0.9$ (雙方談判如何分配£7，折現率=0.9)
  - Player 2 has outside option of £0, £2, or £4 (若不達成協議成員乙仍可獲得£0, £2,或£4)
- Split-the-difference (NBS;平分差額的預測): 50%, 64%, 79%
  - Divide surplus beyond the threat points (雙方平方超出威嚇點以外的部分)
    - Offer player 2: £3.5(=0+7/2), £4.5(=2+5/2), £5.5(=4+3/2)
- Deal-me-out (SPE; 來真的才算數的預測): 47%, 47%, 57%=4/7
  - Rubinstein-Stahl solution is $\left(\frac{1}{1+\delta}, \frac{\delta}{1+\delta}\right)$ (談判解)
  - Unless credible outside option above cutoff $\left(\frac{\delta}{1-\delta}\right)$ (只有當威脅可信時才影響結果所有更小的威嚇點通通不算數)

Outside Option and Threat Points (威嚇點)

Experimental Results

- Deal-me-out wins
  (結果符合來真的才算數)
  - Outside Option £0/£2: spike around 50%
    (£0, £2: 50%附近特別多)
  - Outside Option £4: cluster@57% (£4:集中在57%)
  - Wait 2-3 rounds before accept remaining half

Figure IV: % Player 2 Received (Binmore et al.)



Outside option does affect equilibration!

Outside Option and Threat Points (威嚇點)

Binmore, Proulx, Samuelson & Swierzbinski (EJ 1998)

- Nash Demand Game: Player 1 and player 2 divide \$10
  - State demands x_1, x_2: Split accordingly if $x_1 + x_2 \leq 10$
  - Otherwise, both earn zero
- Outside Option: Player 2 can opt out to earn α for sure
  - $\alpha =$ \$0.90, \$2.50, \$4.90, \$6.40 or \$8.10
- Since most demand \$5, opt out if $\alpha =$ \$6.40 or \$8.10?
  - Forward Induction: Player 2 expects to earn $>\alpha$ if opt in
  - Player 1 should anticipate this and demand $\$(10 - \alpha)$

Outside Option and Threat Points (威嚇點)

Binmore, Proulx, Samuelson & Swierzbinski (EJ 1998)

- Results support Deal-me-out: $x_2 = \max\{\$5, \$\alpha\}$
  - 11-17% player 1 demand >\$(10–α); many player 2s opt out!

BGT, Table 4.8

Value of Option (α)	% of Player 2s Opt Out	Median x_2 if Opt In	Median x_1 if Opt In	% of Player 1s Demand >\$(10–α)
\$0.90	0.0%	\$4.97	\$4.90	0.0%
\$2.50	1.0%	\$4.95	\$4.90	0.0%
\$4.90	33.4%	\$5.00	\$4.65	0.9%
\$6.40	59.8%	\$6.40	\$3.20	11.1%
\$8.10	80.9%	\$8.10	\$1.65	17.0%

95% CI = [\$0.95, \$4.50]

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan and Sopher (book chapter 1991)

- Split R = \$2.40/\$1.20 per period for 4/8 periods
  - Strong player threat point \$1.40/\$0.70: 58% = 7/12 of R
  - Could gain \$1.00/\$0.50 in each; Free-form message online

pie=(Surplus beyond threat point) x T	Game I (pie=\$4)	Game II (pie=\$4)	Game III (pie=\$8)	Game IV (pie=\$8)
Per-period Revenue (R)	\$2.40	\$1.20	\$2.40	\$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	(\$1.40, \$0)	(\$0.70, \$0)	(\$1.40, \$0)	(\$0.70, \$0)
Split-the-difference	(\$7.60, \$2)	(\$7.60, \$2)	(\$15.20, \$4)	(\$15.20, \$4)
Deal-me-out	(\$5.60, \$4)	(\$5.60, \$4)	(\$11.20, \$8)	(\$11.20, \$8)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan and Sopher (1991): Predictions

- Split-the-difference: Split the surplus ($1.00/$0.50)
  - Game I : ($1.40+$0.50)x4 = $7.60 vs. $2.00 = $0.50x4
  - Game II: ($0.70+$0.25)x8 = = $0.25x8

pie=(Surplus beyond threat point) x T	Game I (pie=$4)	Game II (pie=$4)	Game III (pie=$8)	Game IV (pie=$8)
Per-period Revenue (R)	$2.40	$1.20	$2.40	$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	($1.40, $0)	($0.70, $0)	($1.40, $0)	($0.70, $0)
Split-the-difference	($7.60, $2)	($7.60, $2)	($15.20, $4)	($15.20, $4)
Deal-me-out	($5.60, $4)	($5.60, $4)	($11.20, $8)	($11.20, $8)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan & Sopher (bk ch 1991): Predictions

- Deal-me-out: Strong gets threat point ($1.40/$0.70)
  - Game I : $1.40x4 = $5.60 vs. $4.00 = ($2.40 - $1.40)x4
  - Game II: $0.70x8 = = ($1.20 - $0.70)x8

pie=(Surplus beyond threat point) x T	Game I (pie=$4)	Game II (pie=$4)	Game III (pie=$8)	Game IV (pie=$8)
Per-period Revenue (R)	$2.40	$1.20	$2.40	$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	($1.40, $0)	($0.70, $0)	($1.40, $0)	($0.70, $0)
Split-the-difference	($7.60, $2)	($7.60, $2)	($15.20, $4)	($15.20, $4)
Deal-me-out	($5.60, $4)	($5.60, $4)	($11.20, $8)	($11.20, $8)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan & Sopher (bk ch 1991): Predictions

- Split-the-difference: Split the surplus (\$1.00 or \$0.50)
  - Game III:(\$1.40+\$0.50)x 8 = \$15.60 vs. \$4.00 = \$0.50 x 8
  - Game IV:(\$0.70+\$0.25)x16 = = \$0.25 x16

pie=(Surplus beyond threat point) x T	Game I (pie=\$4)	Game II (pie=\$4)	Game III (pie=\$8)	Game IV (pie=\$8)
Per-period Revenue (R)	\$2.40	\$1.20	\$2.40	\$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	(\$1.40, \$0)	(\$0.70, \$0)	(\$1.40, \$0)	(\$0.70, \$0)
Split-the-difference	(\$7.60, \$2)	(\$7.60, \$2)	(\$15.20, \$4)	(\$15.20, \$4)
Deal-me-out	(\$5.60, \$4)	(\$5.60, \$4)	(\$11.20, \$8)	(\$11.20, \$8)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan & Sopher (bk ch 1991): Predictions

- Deal-me-out: Strong gets threat point ($1.40/$0.70)
  - Game I : $1.40x 8 = $11.20 vs. $8.00 = (2.40 - $1.40)x 8
  - Game II: $0.70x16 = = (1.20 - $0.70)x16

pie=(Surplus beyond threat point) x T	Game I (pie=$4)	Game II (pie=$4)	Game III (pie=$8)	Game IV (pie=$8)
Per-period Revenue (R)	$2.40	$1.20	$2.40	$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	($1.40, $0)	($0.70, $0)	($1.40, $0)	($0.70, $0)
Split-the-difference	($7.60, $2)	($7.60, $2)	($15.20, $4)	($15.20, $4)
Deal-me-out	($5.60, $4)	($5.60, $4)	($11.20, $8)	($11.20, $8)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan and Sopher (bk ch 1991): Results

- Joint-cost theory: Shorter strike length in I/III (not supported!)
- Strong/weak get 5-10%/70% surplus: Support Deal-me-out!

pie=(Surplus beyond threat point) x T	Game I (pie=\$4)	Game II (pie=\$4)	Game III (pie=\$8)	Game IV (pie=\$8)
Per-period Revenue (R)	\$2.40	\$1.20	\$2.40	\$1.20
Number of Periods (T)	4	8	8	16
Threat Points (s, w)	(\$1.40, \$0)	(\$0.70, \$0)	(\$1.40, \$0)	(\$0.70, \$0)
Split-the-difference	(\$7.60, \$2)	(\$7.60, \$2)	(\$15.20, \$4)	(\$15.20, \$4)
Deal-me-out	(\$5.60, \$4)	(\$5.60, \$4)	(\$11.20, \$8)	(\$11.20, \$8)
Average Strike Length	0.74	1.17	1.47	1.44
Average Payoffs (s, w)	(\$5.77,\$3.09)	(\$6.49,\$2.53)	(\$11.62,\$6.14)	(\$12.50,\$5.97)

Outside Option and Threat Points (威嚇點)

Forsythe, Kennan and Sopher (book chapter 1991)

- Messages sent mostly verbal tug-of-war between
  - (Everyday) Fairness vs. Game-theoretic Bargaining Power
  - Strong: "I will still earn plenty even if you fail to agree."
  - Weak: Beg for equal divisions/at least split surplus 50-50
- Promise to repay in the next and take large share now
- Other logs:
  - In response to how "cute" he is,
  - "...Are you in a frat[ernity]? If so maybe I'll deal and maybe I won't. Depends on whatever."

Outside Option and Threat Points (威嚇點)

- After breakup: "Go back to Burge [dorm] and roll in the barf,"
- "...I am a junior and live in Mayflower and I'd love for you to stop by sometime and visit"
- Binmore, Morgan, Shaked and Sutton (GEB 1991)
  - Exercise outside option: Exogenous vs. Voluntary
    - Low outside options matter if sometimes exercised exogenously
  - Results do show difference!
- Malleable Fairness: Subject answer to "What division seemed most fair" depends on their own experience

Summary for Random Termination/Outside Options

- Random Termination vs. Discounting Future Payoff
  - Similar results (more rejections under random termination)
- Fixed-Cost Games vs. Fixed-Discounting Games
  - Lopsided Division vs. Equal Splits
  - Can social preferences explain both results?
- Outside Options matter only if yields more than SPE
  - Unlike Nash Bargaining Solution (Split-the-difference)
  - High-option subjects need time to learn they get little surplus

Incomplete Information (資訊不透明)

- Add Asymmetric Information to bargaining
  - 在談判實驗中加入資訊不透明的情形
- More realistic, but (更符合真實)
  - Hard to bargain for a bigger share AND convey information at the same time (但是很難同時傳遞訊息又獅子大開口)
- Might need to turn down an offer to signal patience or a better outside option
  - 可能必須要用拒絕某一方案來展示自己有更好的外部選項

Seller Make Offer to Informed Buyer

- Rapoport, Erev, and Zwick (MS 1995)
- Seller: Own item (worthless to herself) (賣方: 擁有1單位商品留著沒用)
- Buyer: Private reservation price is uniform[0,1]
  - (買方: 保留價格為均勻分配，實際價值只有自己才知道)
- Seller makes an offer each period (每回合賣方提議價格)
- Common discount factor δ (相同的折現率 δ)
  - Unique Sequential Equilibrium (唯一的序列均衡)
  - Seller Offer:
  - (賣方提議) $p_t = p_0 \cdot \gamma^t$

Buyer Accepts if $p_t \leq v \cdot \dfrac{1-\delta}{1-\gamma\cdot\delta}$
(買方接受底線為)

(賣方對保留價格未知的買方提議)

Seller Make Offer to Informed Buyer

- Unique Sequential Equilibrium: (唯一的序列均衡)
- Seller Offer: (賣方提議)

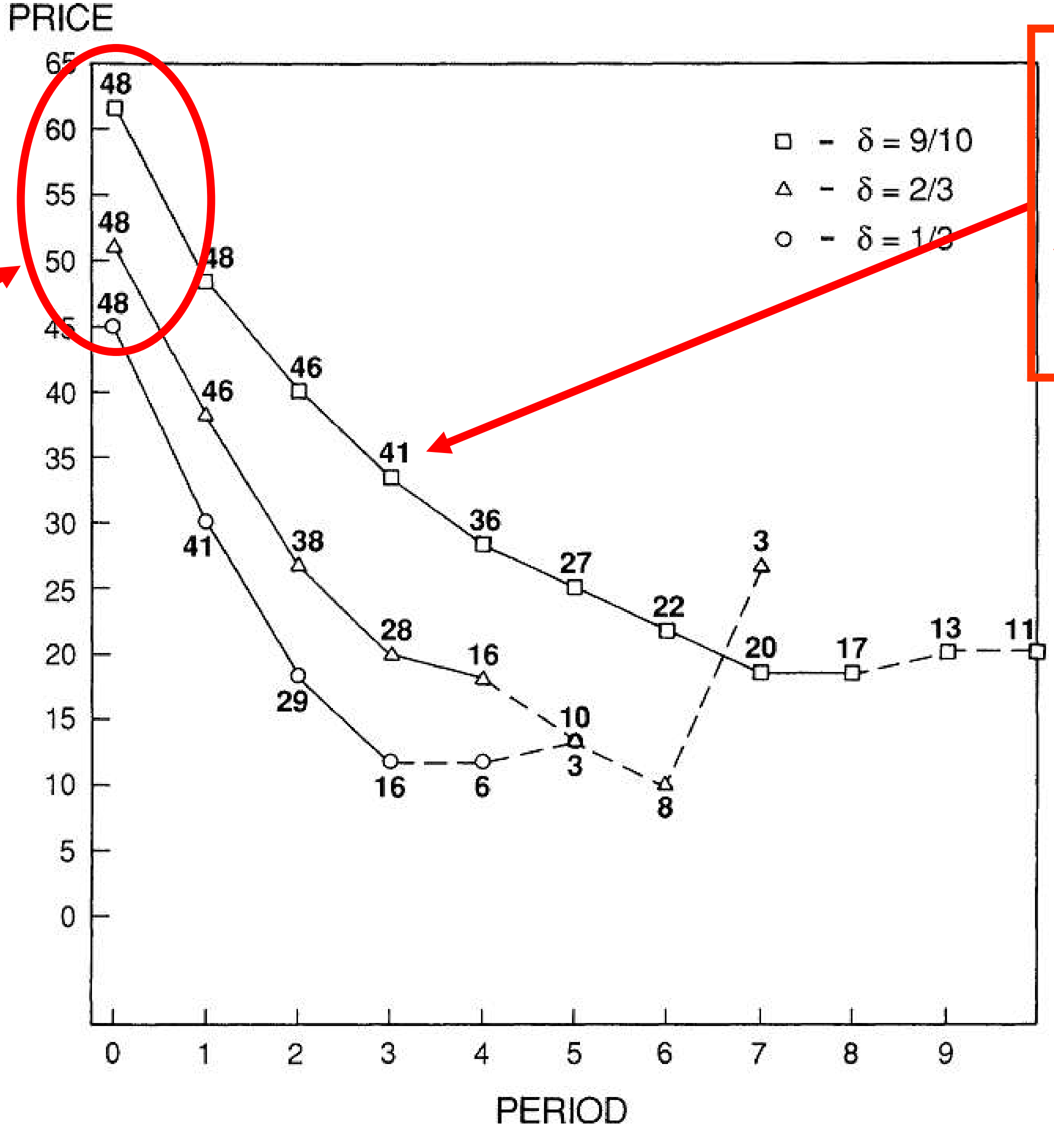
$$p_0 = \gamma \cdot \frac{1-\delta}{1-\gamma\cdot\delta},$$

- Subsequently: $p_t = p_0 \cdot \gamma^t,$ $\qquad \gamma = \dfrac{1-\sqrt{1-\delta}}{\delta}$
  - (接下來)
- Buyer Accepts if $p_t \leq v \cdot \dfrac{1-\delta}{1-\gamma\cdot\delta}$
  - (買方接受底線為)

Seller Make Offer to Informed Buyer

- Complicate Strategy: Depend on δ (均衡策略很複雜且跟 δ 有關)
  - Price discriminate high/low-value buyers
  - Price declines slow enough so high-value buyers will not want to wait (對保留價格不同的買方實施價格歧視，價格下降速度慢到讓高保留價格者不願意等待。但受試者做得到嗎?)
- Can subjects get these in experiments?
  - Different δ : H (0.90), M (0.67), L (0.33) (不同折現率)
  - Opening p_0: H (0.24), M (0.36), L (0.45) (初始出價)
  - Discount γ : H (0.76), M (0.68), L (0.55) (降價幅度)

Seller Make Offer to Informed Buyer



Initial offer too high!

(初始出價太高!)

Decline Rate Amazingly Close!

(但降價幅度很接近理論預測)

Seller Make Offer to Informed Buyer

- Can subjects get these in experiments?
  - Different δ: H (0.90), M (0.67), L (0.33) (不同折現率)
  - Opening p_0: H (0.24), M (0.36), L (0.45) (初始出價)
  - Discount γ : H (0.76), M (0.68), L (0.55) (降價幅度)
- Buyers accept the 1st or 2nd offer below v (出價$<v$ 一兩回合就接受)
  - Accept offers too soon (買方接受得太早/應該再等一會兒)
- Sellers ask for higher prices (than equilibrium)
  - 跟均衡相比，賣方初始出價太高，但實際降價幅度非常接近理論預測
  - But empirical discount γ : H (0.81), M (0.68), L (0.55)

Strikes and 1-Sided Information (資訊不透明與罷工)

- Forsythe, Kennan and Sopher (AER 1991)
  - Only Informed bargainer I sees pie size π_g or π_b (只有一方 I 知道總金額)
- Uninformed U can strike to shrink pie by γ (不知情的一方 U 可罷工使金額縮水 γ)
- What happens in free-form bargaining? (自由談判的實驗結果會如何?)
- Myerson (1979): Revelation Principle (顯示真實原則)

1. I announces true state (I 宣布真實狀況)
2. U strikes to shrink pie by γ_g or γ_b (U 罷工會讓金額變成 γ_g 或 γ_b)
3. I gives U (based on true state) x_g or x_b (根據真實狀況 I 給 U x_g 或 x_b)

Strikes and 1-Sided Information (資訊不透明與罷工)

- IC requires: (誘因符合限制式)

$$(\gamma_g - \gamma_b)\pi_b \le x_g - x_b \le (\gamma_g - \gamma_b)\pi_g$$

- Interim Incentive Efficiency requires: (中間誘因效率)

$$\gamma_g = 1, x_g - x_b = (1 - \gamma_b)\pi_g$$

- Strike (γ_b <1) if and only if $p\pi_g > \pi_b$
  - 罷工 (γ_b <1) 的充分必要條件
- Deriving this is complicated... (解出這些條件很複雜...)
  - Could ANY subject get close to this? (會有人解出來嗎?)

Strikes and 1-Sided Information (資訊不透明與罷工)

- Random Dictator (RD) Axiom: (隨機獨裁分配公設)
  - Agree fair mix between each being dictator to propose mechanism (同意隨機決定由誰獨裁決定分配機制)
- Then: (則)

$$\gamma_g = 1, x_g = \frac{\pi_g}{2}, \gamma_b = \frac{1}{2}, x_b = 0 \text{ if } p\pi_g > \pi_b$$

$$\gamma_g = 1, x_g = \frac{\pi_b}{2}, \gamma_b = 1, x_b = \frac{\pi_b}{2} \text{ if } p\pi_g < \pi_b$$

Strikes and 1-Sided Information (資訊不透明與罷工)

- This is a win-win experiment: (這是一個雙贏實驗)
  - Success if theory predictions are close (如果結果符合理論預測就驗證了理論)
  - If not, will point to which assumption fails (不符合可看出哪個假設出問題)
- Forsythe, Kennan and Sopher (AER 1991): (文字溝通10分鐘)
  - 10 minute sessions; written messages
- Is Myerson (1979) confirmed? (顯示真實原則是否被驗證?)
  - Surprisingly yes, though not perfect... (出乎意料地正確，但是還不夠完美...)

Strike Condition Off (罷工條件不成立) $p\pi_g < \pi_b$

Game (賽局)	p	State (狀況)	π	π_U	π_I	Total (加總)	Strike (罷工)
III	0.5	b	2.80				
		g	4.20				
		aver.	3.50	1.50	1.80	3.29	6.0%
		pred.		1.40	2.10	3.50	0.0%
IV	0.25	b	2.40				
		g	6.80				
		aver.	3.50	1.21	2.04	3.24	7.4%
		pred.		1.20	2.30	3.50	0.0%

Strike Condition Off (罷工條件不成立) $p\pi_g < \pi_b$

Game (賽局)	p	State (狀況)	π	π_U	π_I	Total (加總)	Strike (罷工)
III	0.5	b	2.80	1.47	1.18	2.66	5.2%
		g	4.20	1.52	2.41	3.93	6.5%
		aver.	3.50	1.50	1.80	3.29	6.0%
		pred.		1.40	2.10	3.50	0.0%
IV	0.25	b	2.40	1.08	1.04	2.12	11.8%
		g	6.80	1.58	5.03	6.61	2.9%
		aver.	3.50	1.21	2.04	3.24	7.4%
		pred.		1.20	2.30	3.50	0.0%

Strike Condition On (罷工條件成立) $p\pi_g > \pi_b$

Game (賽局)	p	State (狀況)	π	π_U	π_I	Total (加總)	Strike (罷工)
I	0.5	b	1.00				
		g	6.00				
		aver.	3.50	1.05	2.00	3.05	13.0%
		pred.		1.50	1.75	3.25	7.1%
II	0.75	b	2.30				
		g	3.90				
		aver.	3.50	1.41	1.76	3.18	9.3%
		pred.		1.46	1.75	3.21	8.3%

Strike Condition On (罷工條件成立) $p\pi_g > \pi_b$

Game (賽局)	p	State (狀況)	π	π_U	π_I	Total (加總)	Strike (罷工)
I	0.5	b	1.00	0.31	0.30	0.61	39.0%
		g	6.00	1.78	3.70	5.48	8.7%
		aver.	3.50	1.05	2.00	3.05	13.0%
		pred.		1.50	1.75	3.25	7.1%
II	0.75	b	2.30	1.06	0.84	1.90	17.2%
		g	3.90	1.53	2.07	3.59	7.9%
		aver.	3.50	1.41	1.76	3.18	9.3%
		pred.		1.46	1.75	3.21	8.3%

Sealed-Bid in Bilateral Bargaining (密封投標的雙邊談判)

- Both buyers and sellers have private information (買賣雙方都各自知道自己的成本/保留價格)
- Sealed-Bid Mechanism (密封投標機制)
  - Both write down a price (雙方都寫下一個價格)
  - Trade at the average if $p_b > p_s$ (當$p_b > p_s$則以均價成交)
  - Call Market: Many buyers vs. many sellers (公開喊價: 許多買方 vs. 許多賣方)
- Two-Person Sealed-Bid Mechanism
  - One form of bilateral bargaining (雙人密封投標機制: 一種特定的雙邊談判)

Two-Person Sealed-Bid Mechanism (雙人密封投標機制)

- Buyer V: uniform[0,100]; Seller C: uniform[0,100]
  - 買方價值 V 賣方成本 C
- Piecewise-linear Equilibrium: (not unique)
  - Chatterjee and Samuelson (1983) (一個分段線性均衡)
  - Myerson and Satterthwaite (1883): Maximize ex ante gains (極大化事前報酬)

$$p_b = \begin{cases} V & \text{if } V < 25 \\ \frac{25}{3} + \frac{2}{3}V & \text{if } V \geq 25 \end{cases}$$

$$p_s = \begin{cases} 25 + \frac{2}{3}C & \text{if } C < 75 \\ C & \text{if } C \geq 75 \end{cases}$$

Two-Person Sealed-Bid Mechanism (雙人密封投標機制)

- Radner and Schotter (JET 1989): 8 sessions
- 1, 2, 8: Baseline as above (場次1,2,8為對照組/如上所述)
- 3: Trade at price $(v + c + 50)\ /\ 3$ if $v > (c+25)$
  - Should bid their values $v = V$, $c = C$ (場次3改變交易價格決定方式，讓誠實下標買方價值/賣方成本為上策)
- 4: Price $= v$, (Buyers should bid $v = V/2$) (場次4價格為買方出價;買方出價應為價值之半/場次5,6改分配增加學習)
- 5,6: Alternative distribution for more learning
  - Distribution with more trade (for learning): $m{=}0.438$
- 7: Face-to-face bargaining (場次7為面對面談判)

Estimated Seller Bid Function Slope (用資料估計賣方出價函數斜率)

Session (場次)	Below Cutoff (前段) β	Below Cutoff (前段) $\hat{\beta}$	t-stat (t值)	Above Cutoff (後段) β	Above Cutoff (後段) $\hat{\beta}$	t-stat (t值)
1	0.67	0.58	(-1.38)	1	0.97	(-0.32)
2	0.67	0.74	(1.28)	1	1.07	(0.14)
8	0.67	0.75	(1.65)	1	1.07	(0.17)
3	1	1.06	(1.04)	1	0.67	(-0.58)
5	0.438	0.48	(0.87)	1	1.00	(0.60)
6 (-20)	0.438	0.57*	(2.16)	1	0.97	(-0.79)
6 (21-)	0.438	0.52	(1.20)	1	0.95	(-0.69)

	Below Cutoff (前段)			Above Cutoff (後段)		

Estimated Buyer Bid Function Slope (用資料估計買方出價函數斜率)

Session (場次)	β	$\hat{\beta}$	t-stat (t值)	β	$\hat{\beta}$	t-stat (t值)
1	1	1.00	(0.01)	0.67	0.85*	(4.14)
2	1	0.91	(-0.52)	0.67	1.06	(1.28)
8	1	0.91	(-0.14)	0.67	0.80*	(2.32)
3	1	0.92	(-0.88)	1	0.73*	(-2.64)
4	0.5	0.55	(0.66)	0.5	0.58*	(2.32)
5	1	0.80*	(-4.17)	0.438	0.50	(1.12)
6 (-20)	1	0.85	(-1.40)	0.438	0.40	(0.56)
6 (21-)	1	1.11	(0.70)	0.438	0.32	(-1.55)

Face-to-face Yields 110% Efficiency (面對面可達到110%效率)

- Some truthfully reveal; others do not (因部分人講真話)
- Radner and Schotter (JET 1989, p.210):
  - The success of the face-to-face mechanism, if replicated, might lead to a halt in the search for better ways to structure bargaining in situations of incomplete information.
    (如果面對面談判的成功可重複驗證，那也許就不必再費心尋找資訊不全下、更好的制式談判方式了)
  - It would create, however, a need for a theory of such structured bargaining in order to enable us to understand why the mechanism is so successful.
    (反而需要更好的制式談判理論來解釋為什麼面對面的方式這麼成功)

Follow-up Studies (後續研究)

- Schotter, Snyder and Zheng (GEB 2000)
  - Subjects draw valuations from asymmetric distribution as in Session 5-7 of Radner and Schotter (1989)
    - Distribution with more trade (for learning): $m=0.438$
- Let agents bargains face-to-face for you (派代表幫你談判)
  - Buyers tell agent maximum willing-to-bid
  - Sellers tell agent minimum willing-to-bid
  - Agents paid percentage of surplus/fixed fee for each trade

Follow-up Studies (後續研究)

- Results of Schotter, Snyder and Zheng (GEB 2000):
  - Give maximum reservation price below true valuation
  - m=0.78 with percentage-fee vs. m=0.70 with fixed-fee
    - Between predicted m=0.438 and truthful revelation (m=1)
- Rapoport and Fuller (1995)
  - Replicate Radner and Schotter (1989) with:
  - Strategy method and asymmetric value distribution
    - 詢問完整策略、買方價值/賣方成本分配不對稱

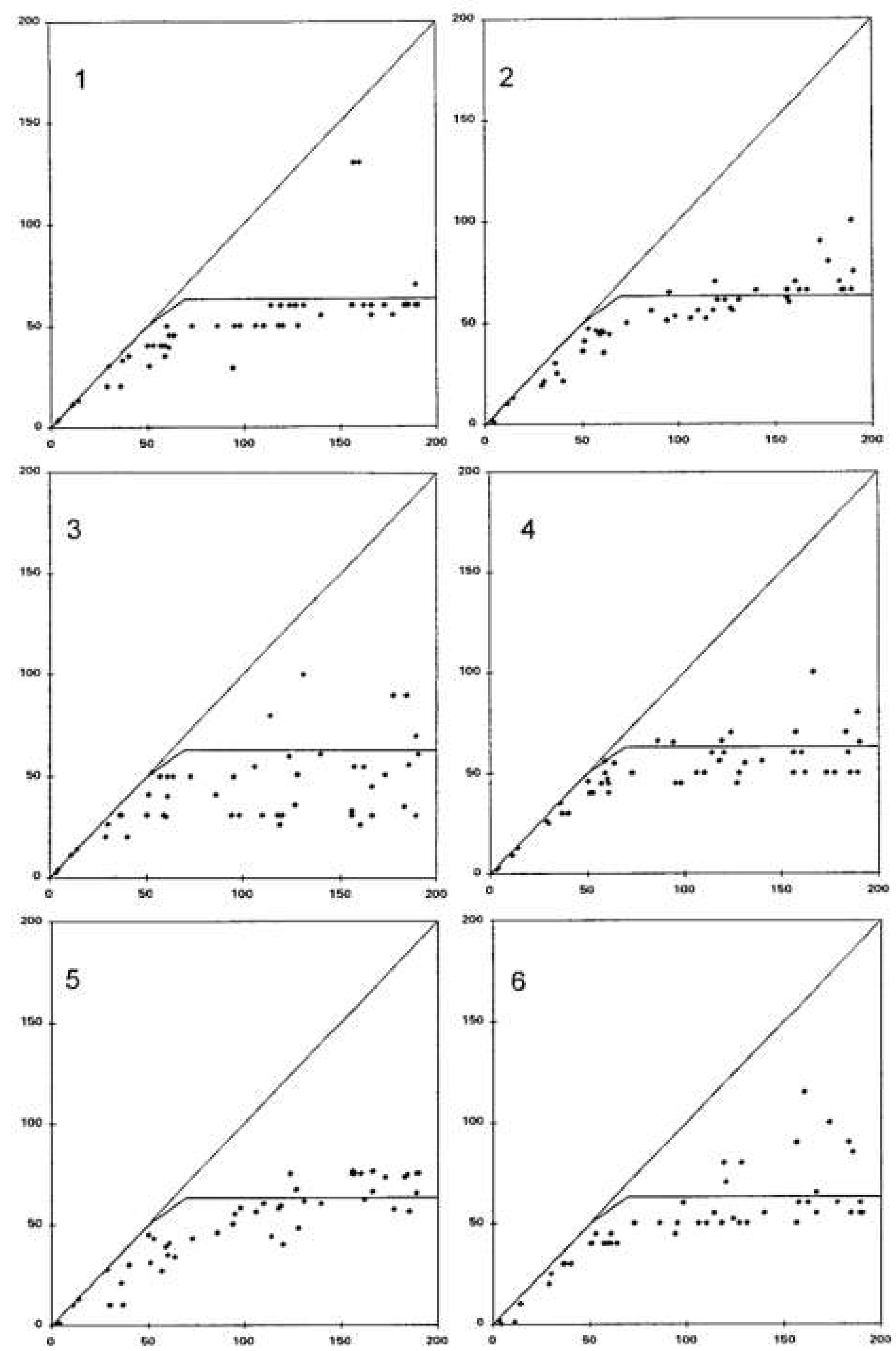
Follow-up Studies (後續研究)

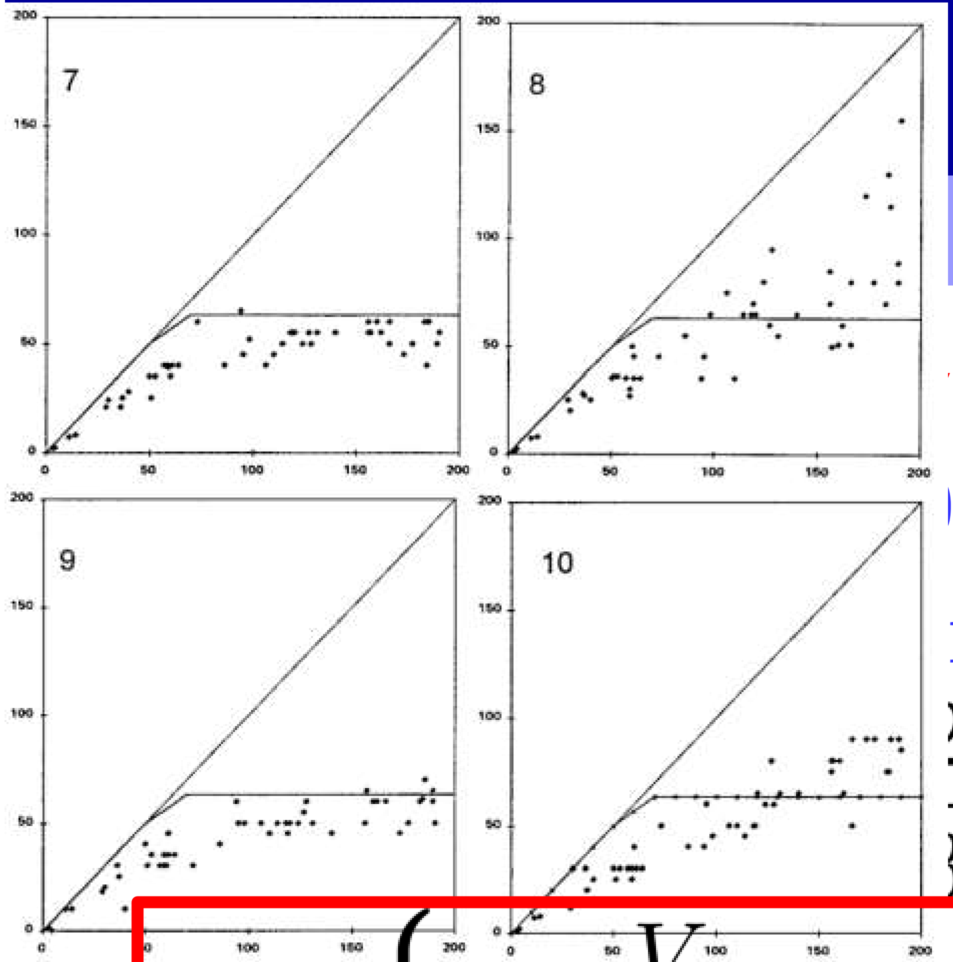
- Daniel, Seale and Rapoport (J Math Psych 1998)
  - Experiment 1 replicate asymmetric value distribution (R-F)
- Buyer V: uniform[0, 200]; Seller C: uniform[0, 100]
- Linear bid function for seller: $p_s = 50 + \frac{2}{3}C$
- Piecewise-linear bid function for buyer: $p_b = \begin{cases} V & \text{if } V < 50 \\ \frac{50}{3} + \frac{2}{3}V & \text{if } V \in [50, 150] \\ 116.7 & \text{if } V > 150 \end{cases}$
  - $\hat{m}$=0.56 (near 2/3)
  - $\hat{m}$=0.28 (near 0)

Follow-up Studies (後續研究)

- Daniel, Seale and Rapoport (J Math Psych 1998)
  - Experiment 2: Extremely asymmetric value distribution
- Buyer V: uniform[0, 200]; Seller C: uniform[0, 20]
- Linear bid function for seller: $p_s = 50 + \frac{2}{3}C$ (Way above cost!!)
- Piecewise-linear bid function for buyer: $p_b = \begin{cases} V & \text{if } V < 50 \\ \frac{50}{3} + \frac{2}{3}V & \text{if } V \in [50, 70] \\ 63.3 & \text{if } V > 70 \end{cases}$

(Almost always flat!!)





ch 1998)

vs. 200)

rm[0, 20]

C (Way above cost!!)

er: $p_b = \begin{cases} V & \text{if } V < 50 \\ \frac{50}{3} + \frac{2}{3}V & \text{if } V \in [50, 70] \\ 63.3 & \text{if } V > 70 \end{cases}$

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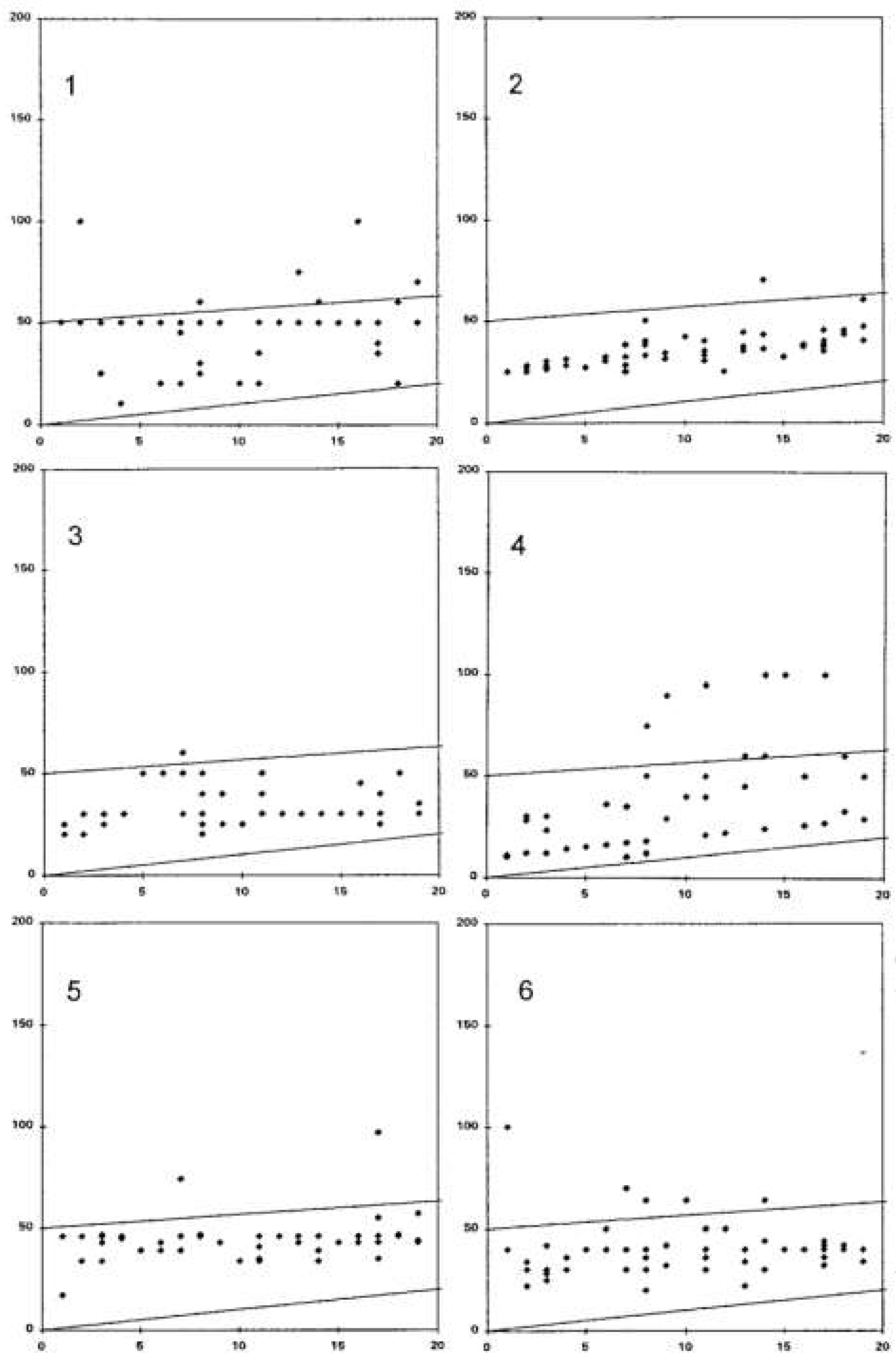
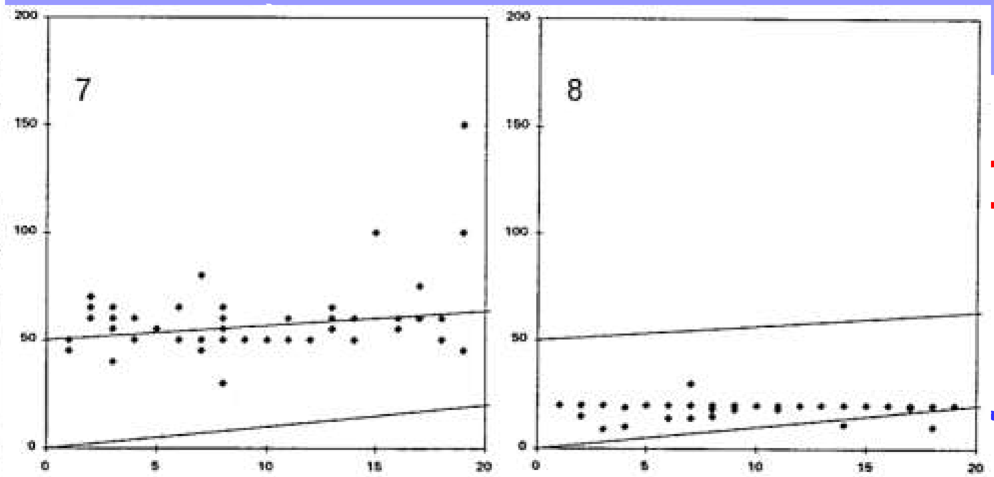


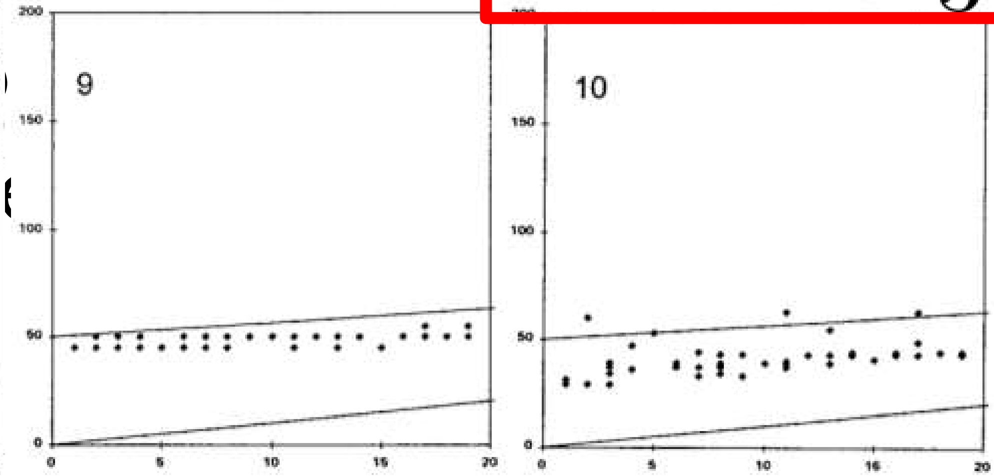


ch 1998)

vs. 200)

m[0, 20]

n for seller: $\boxed{p_s = 50 + \frac{2}{3}C}$ (Way above cost!!)



if $V < 50$

if $V \in [50, 70]$

if $V > 70$

(Almost always flat!!)

Follow-up Studies (後續研究)

- Daniel, Seale and Rapoport (1998): Experiment 1
  Buyer V: uniform[0, 200]; Seller C: uniform[0, 100]

$$p_b = \begin{cases} V & \text{if } V < 50 \\ \frac{50}{3} + \frac{2}{3}V & \text{if } V \in [50, 150] \\ 116.7 & \text{if } V > 150 \end{cases} \qquad p_s = 50 + \frac{2}{3}C$$

	Buyer (Value Range)			Buyer	Seller		
	0-50	51-150	151-200	R^2	α	β	R^2
Prediction	1.00	0.67	0.00	-	50.0	0.67	-
Mean (DSR-Exp1)	0.88	0.61	0.16	0.87	39.0	0.73	0.67
Median(RDS-Exp1)	0.89	0.64	-0.08	0.88	26.3	0.84	0.83

Follow-up Studies (後續研究)

- Daniel, Seale and Rapoport (1998): Experiment 2
  Buyer V: uniform[0, 200]; Seller C: uniform[0, 20]

$$p_b = \begin{cases} V & \text{if } V < 50 \\ \frac{50}{3} + \frac{2}{3}V & \text{if } V \in [50, 70] \\ 63.3 & \text{if } V > 70 \end{cases} \qquad p_s = 50 + \frac{2}{3}C$$

	Buyer (Value Range)			Buyer	Seller		
	0-50	51-70	71-200	R^2	α	β	R^2
Prediction	1.00	0.67	0.00	-	50.0	0.67	-
Median(DSR-Exp2)	0.78	0.46	0.21	0.76	39.0	0.73	0.67

- Overbid in first 10 rounds, then learn to bid much lower

Follow-up Studies (後續研究)

- Rapoport, Daniel and Seale (1998): Experiment 2
  Seller C: uniform[0, 200]; Buyer V: uniform[100, 200]
  - Flip buyer-seller asymmetry; fixed pairing (買方價值/賣方成本的分配不對稱反過來、固定配對)

$$p_s = \begin{cases} 83.3 & \text{if } C < 50 \\ 50 + \frac{2}{3}C & \text{if } C \in [50, 150] \\ C & \text{if } C > 150 \end{cases}$$

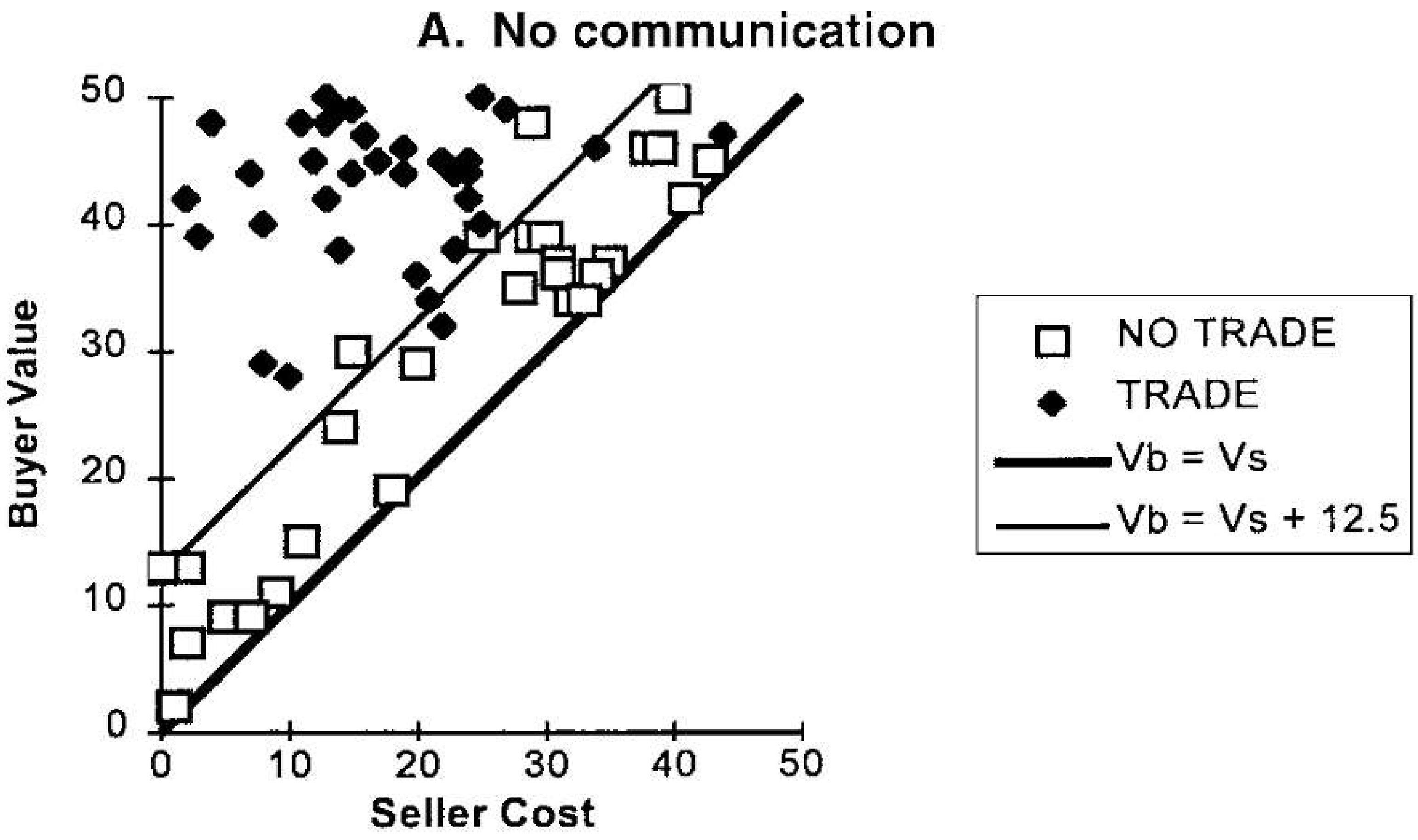
$$p_b = 16.7 + \frac{2}{3}V$$

	Seller (Cost Range)			Seller	Buyer		
	151-200	51-150	0-50	R^2	α	β	R^2
Prediction	1.00	0.67	0.00	-	16.7	0.67	-
Median(RDS-Exp2)	0.95	0.62	0.05	0.91	15.0	0.71	0.80

Communication vs. Sealed-Bid (溝通 vs. 密封投標)

- Valley et al. (GEB 2002): Communication (溝通)
- Buyer/Seller Values/Costs: uniform[0, $50]
  - 買方價值/賣方成本的分配都是 uniform[0, $50] (透過出價來談判)
  - Bargain by stating bids; 7 periods; no rematch
  - Half had no feedback (七回合不重複配對/一半沒有看結果)
- No communication: Sealed-bid in 2 minutes (沒有溝通: 2分鐘內密封投標)
- Written communication: Exchange messages for 13 minutes before final bid (文字溝通: 13分鐘傳紙條交換意見)
- Face-to-face: Pre-game communication (當面: 事前溝通)

Communication vs. Sealed-Bid (溝通 vs. 密封投標)



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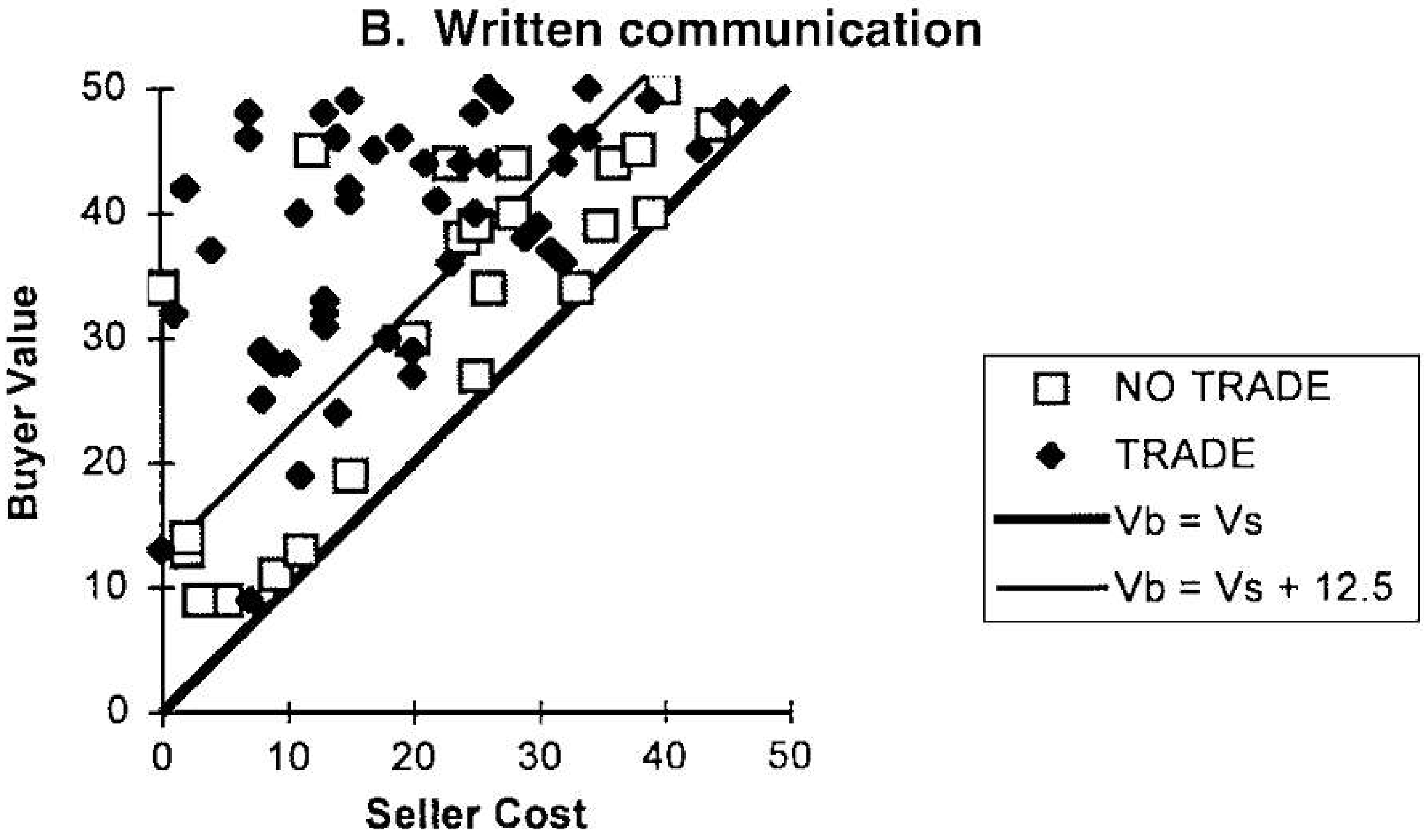
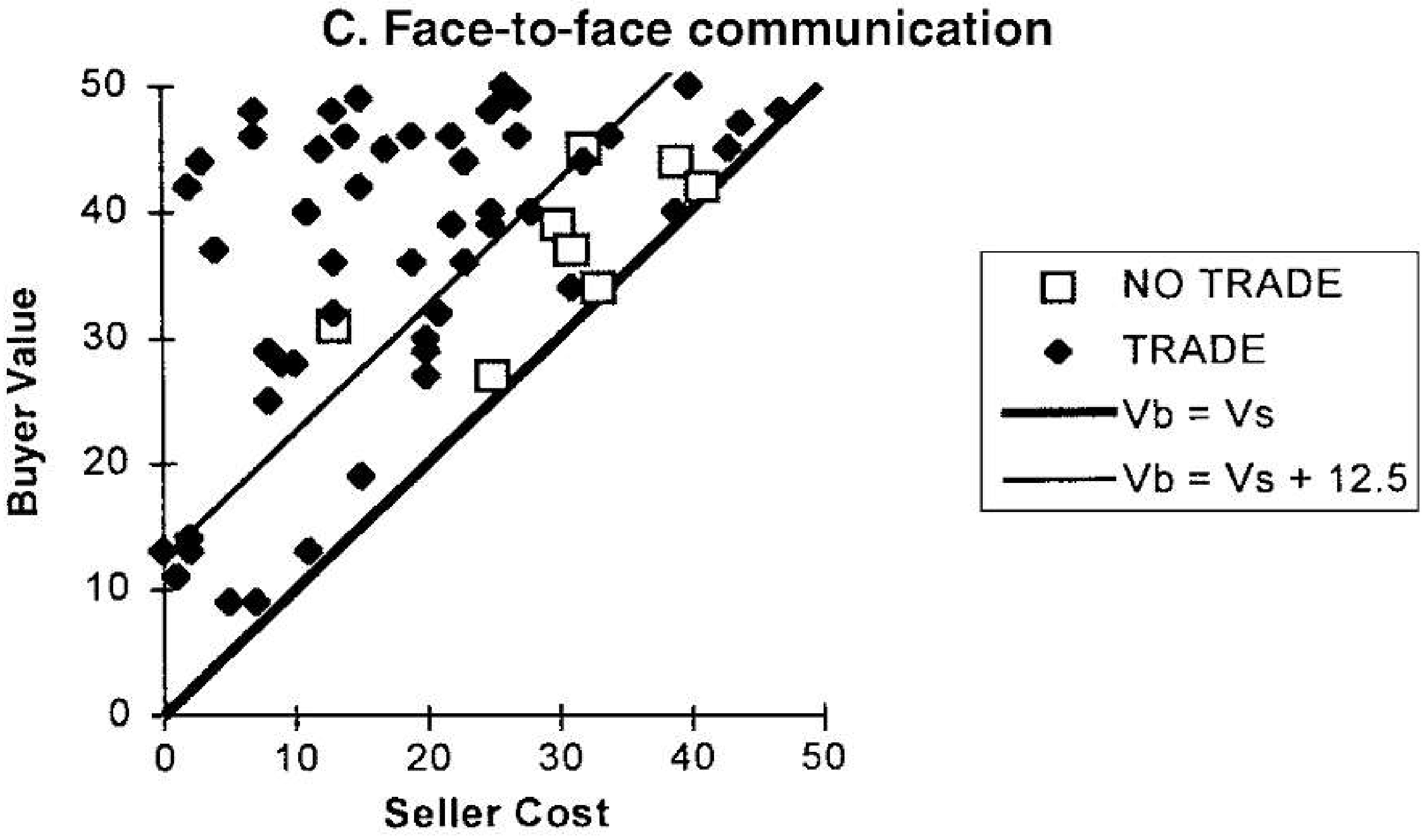


Communication vs. Sealed-Bid (溝通 vs. 密封投標)



Communication vs. Sealed-Bid (溝通 vs. 密封投標)

- Empirical bid function slope = 0.7 (near 2/3)
  - 實驗資料估計出來的出價函數斜率(=0.7)接近三分之二
- Why are there "gains of communication"?
  - 「溝通的好處」哪來?
- Slope of buyer bids against seller bids=0.6
- Buyers bid higher when seller bids higher
  - 賣家出價約為買家的六成且賣家出價愈高、買家出價愈高
  - Mutual bidding of values (common in students)
  - Mutual revelation of values (common in students)
    - (學生受試者更傾向)一起用真實價值/成本出價或一起揭露

Communication vs. Sealed-Bid (溝通 vs. 密封投標)

- Coordinating on a price (40%文字/70%當面協調相同出價)
  - Happens 40% in written, 70% in face-to-face
- Not truth-telling (only 1/3) (講真話只有1/3且未協調)
  - TT not coordinated (4% written, 8% face)
- Feel each other out; give enough surplus
  - Modal – equal split of surplus (彼此試探後給足交易好處)
- Variance of surplus doubles (by mismatch)
  - (大多平分交易好處，但交易好處的變異數倍增，因為協調不成)

Summary for Asymmetric Information

- More Realistic!
  - Bargainers know their V, others only know the asymmetry
- Experimental Results surprisingly support theory!
  - One-sided bargaining: Sellers make sequential offers
    - Initial offer too high, but decline at predicted rates
  - Strike as predicted if bargain over large/small surplus
  - Sealed-bid mechanism: Confirm piece-wise linear equilibrium
  - Pre-play Communication: Efficiency higher than predicted
    - Used by players to agree on (self-enforcing) one-price equilibrium

Conclusion (結論)

- Unstructured Bargaining (自由談判: 焦點/競爭的焦點)
  - Focal divisions; competing focal points
  - Self-serving bias (erased by veil of ignorance or stating weakness of own case) (自立偏誤可以無知之幕或找己方弱點抗衡)
- Structured Bargaining (制式談判)
  - Deviate toward equal splits (朝平分偏離均衡預測/因社會偏好?)
  - Social preference models could explain this
  - But Johnson et al. (JET 2002) suggest deviation due to limited look-ahead (但MouseLAB結果顯示也可能來自無法「無限往前看」的有限理性)

Conclusion (結論)

- Outside options affect bargaining divisions only if threats are credible (威嚇點來真的才算數)
  - Lower fixed cost player gets everything (延遲成本低全拿)
- Information Asymmetry: One-Sided (單邊資訊不對等)
  - Revelation Principle + Random Dictator: Good
  - 顯示真實原則+隨機獨裁者公設的預測被實驗結果證實
  - Bazaar mechanism: (檢驗賣家一再降價直到買家接受的機制)
    - Offers decline as theory predicts, but start too high and respond to δ wrongly since buyers accept too early (降價幅度符合預測，但是初始開價太高，因買家會太快接受)

Conclusion (結論)

- Bilateral Bargaining: Two-Sided (雙邊資訊不對等談判)
  - Sealed-bid mechanism (密封投標機制)：between truthful revelation & piecewise-linear equilibrium
- Players over-reveal values in face-to-face
  - Too honest, but "more efficient" (當面太誠實/超效率)
  - Communication $\longrightarrow$ agree on a single price (溝通→合意單一價格)
- Why theory does better in sealed-bid than alternative-offer bargaining? (為何密封投標比反覆提議更合乎理論?)
  - Is sealed-bid cognitively more transparent?